



Mills & Co. Lith. Des Moines.

VIEW OF BLUFFS AT CRESCENT STATION.(N.W.R.R

6 Miles above Council Bluffs Iowa , 1868.

(Looking South east.)

REPORT
ON THE
GEOLOGICAL SURVEY

OF THE
STATE OF IOWA,

TO THE THIRTEENTH GENERAL ASSEMBLY, JANUARY, 1870, CONTAINING
RESULTS OF EXAMINATIONS AND OBSERVATIONS MADE WITHIN
THE YEARS 1866, 1867, 1868, AND 1869.

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PART I.

COUNTY AND REGIONAL GEOLOGY.

CHAPTER I.

GEOLOGY OF THE MIDDLE REGION OF WESTERN IOWA AND OTHER COUNTIES.

1. GEOGRAPHICAL AREA.

The middle region of Western Iowa embraces that portion of the State included in the fourth, fifth, and sixth tiers of counties lying between the Des Moines and Missouri rivers; the former stream forming its eastern and the latter the western boundary of the district. The district as thus defined contains a superficial area a little upwards of 8,600 square miles, including thirteen full counties and portions of three others, as follows : Woodbury, Monona, Harrison, Shelby, Crawford, Audubon, Ida, Sac, Calhoun, Carroll, Greene, Guthrie, Dallas, and portions of Polk, Boone, and Webster counties.

2 PHYSICAL FEATURES.

This region is traversed nearly centrally in a north and south direction by the Great Watershed, separating the drainage of the Mississippi on the one hand from that of the Missouri river on the other. Many of the streams upon both slopes take their rise in the watershed plateau, within

this district, while others and the more important head in the great plain to the northward, some of them within the boundaries of this State, and others beyond its borders in the State of Minnesota.

The streams upon the west slope of the watershed have a southerly or southwesterly direction and mostly gain the Missouri within the borders of the State. The principal of these are the Nishnabotany, Boyer, Soldier, Maple, Little Sioux and the West Fork, and Floyd rivers, besides many smaller watercourses, some of them tributaries of those just named, and others which reach the Missouri independently, or are lost in the loose deposits which compose the great bottom-plain of the Missouri. Their valleys are deeply eroded into the superficial deposits, which constitute the main geological features to be observed in this portion of the district, and have a depth of from one hundred to two and even three hundred feet along their lower courses. The Missouri winds through the great bottom-plain which borders its banks upon either side, from five to ten and sometimes fifteen miles in width, over a treacherous bed of sands which afford no stability to the channel, which is changed with almost every flood. The great periodic freshet resulting from the melting of the snows far to the northwest in the region of its sources, takes place usually in the month of June, inundating all the lower portions of the adjacent bottoms; here eating away acres of land and there building up wide flats of sand which in a few seasons becomes covered with a rank growth of willow and cottonwood, which serve to retain the rich sediments brought down by subsequent floods, and thus are formed some of the most fertile tracts in an incredibly short time.

The drainage upon the east slope in this district is performed entirely by the affluents of the Des Moines, which have a southerly course or nearly at right angles to that of the streams to the west of the Great Watershed. This section is watered by the Raccoon rivers, whose valleys are abruptly defined by steep acclivities largely composed of the

detrital material of the Drift, offering many marked contrasts to the valleys found upon the opposite side of the great divide, as does also the surface configuration of the country through which they pass, and which are dependent upon the character of the superficial deposits which prevail, respectively, in the regions separated by the watershed that defines the two great systems of drainage in the State, and which in this district also marks the eastern limit of the remarkable deposit known as the Bluff formation, as will be noticed further on.

The principal portion of the district presents an uninterrupted prairie. In the west the surface is rolling, while the eastern half of the district presents a gently undulating surface, characteristic of the Drift region. The forest growths are mainly restricted to the valleys, though sometimes considerable tracts of upland are overgrown with thrifty timber, or stunted oak openings. Mr. J. A. Allen, of Cambridge, who has given the subject of the distribution of forests in the prairie regions of Iowa and Illinois a careful study, has observed that the bulk of the woodland is found along the south sides of the valleys. He is inclined to attribute the prevalence of forest growth upon the declivities facing the north, to the more favorable conditions there existing for their propagation and preservation in the greater amount of moisture gathered and retained upon the shaded declivities, than upon those which are exposed to the full influence of the sun's rays. His views, so far as our observations have extended in the State, agree perfectly with what we have here observed, and seem to be founded in fact; for, wherever the valleys take a northerly and southerly course, we find the forests about equally distributed upon both sides. But by no means is the growth of trees upon our prairies dependent upon the above mentioned conditions of moisture. However great influence moisture has exerted in sustaining forest growths against the almost resistless attacks of the prairie fires, while the country was in its wild state, so soon as the prairies become settled and cultivation restricts or wholly

subdues the ravages of the fires, forests begin a rapid encroachment upon the former prairie slopes, and finally overspread all portions of the upland not otherwise occupied by the improvements of the farmers.

3. GEOLOGY.

In many respects there is hardly a more interesting field for geological research in the State than that afforded by the district at present under consideration. Its entire area is heavily enveloped in the superficial deposits pertaining to the Post-tertiary period, which alone offers a field of most instructive study, which has a more or less direct bearing on the development of the agricultural interest of the country, but the investigation of which has been, as yet, barely begun. From beneath these deposits all three members of the coal-measures appear in the southeastern portion of the district, where the characteristics of each are well displayed. Also the Lower Cretaceous formations outcrop over more or less limited areas, where they are sufficiently well defined to enable a tolerably accurate knowledge to be gained of the geographical distribution and the stratigraphical order of the strata of this period within the boundaries of the State.

4. POST-TERTIARY.

The Post-tertiary period is represented by the Drift and Bluff deposits. The *Drift*, as it is at present understood, is made up of (1) The glacial deposits, consisting of blue clays charged with sand, gravel, and boulders, without order in their arrangement; and, (2) The modified drift, which is composed of yellow sandy deposits and the loose materials derived from the breaking up or erosion of the former deposits during the draining of the shallow waters that accumulated immediately following the glacial epoch. This latter deposit is almost co-extensive with that of the unmodified or glacial deposit, from which it differs, in as much as the materials of which it is made up are always in a more or

less distinctly stratified condition, such as would result from the action of currents in shallow waters.

Both of these deposits are extensively developed in the country lying between the watershed and the Des Moines river. In the immediate region of the watershed, the Drift probably attains its greatest thickness; but at the same time it would appear that this great ridge is of pre-glacial origin, since we find the Cretaceous deposits outcropping high upon its flanks, and evidently still forming a large portion of its bulk. As we pass to the westward, however, these deposits gradually diminish in thickness, and on approaching the Missouri they present but a thin, irregular bed, and are often wholly wanting. That they were once fully represented in this region, there can be little doubt; for even now at certain localities, where they have escaped the denuding agencies which prepared the great basin of the Missouri for the reception of the subsequent deposit of the Bluff epoch, they present much the aspect usually observed in connection with these beds in the central portion of the State.

In eastern and central Iowa, the Terrace epoch is also represented by the peculiar and interesting formations which occupy the valleys in that portion of the State. In the valleys of the Raccoon rivers, as also in that of the Des Moines, the terraces are beautifully displayed, being composed largely of gravel and sand which present all varieties of stratification usually observed in connection with these deposits elsewhere. They are readily distinguishable from the *modified drift* of the uplands by the more definite arrangement of their component materials, as well as by their symmetrical step-like form. But proceeding westward, we no sooner surmount the watershed than we lose all trace of these interesting formations, except it be an occasional obscure remnant of an outlier, as may be seen in the valley of the Boyer, near Denison, where one such occurs in the valley-side from which quantities of gravel have been obtained for the manufacture of concrete blocks.

The deposit of the Bluff epoch constitutes the most

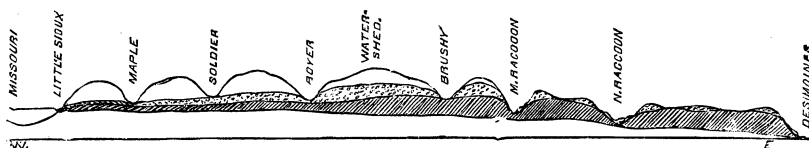
important feature in the surface geology of the district, as it does also of the western portion of the State. It is referred by Dr. White to lacustral origin, and overspreads the entire country from the Missouri river to the watershed divide on the east, which in this district more or less accurately defines its eastern limits. However, in Guthrie county, whose western confines rest upon the great divide, the Bluff Deposit overlays, so to speak, the watershed and caps the divides on the Mississippi slope between the South Raccoon and the Brushy Fork, and that between the latter stream and the Middle Raccoon. But to the northward in Carroll county, the deposit forms but a comparatively thin layer upon the summit of the main watershed, and thence the border of the deposit is defined by a line pursuing a west-northwest course across the southwest corner of Buena Vista and thence through Cherokee and Plymouth counties, terminating on the Big Sioux in the northern portion of the latter county.

It was observed that the Drift Deposits gradually thin to the westward on leaving the great divide, but directly the opposite occurs in the case of the present deposit which rapidly increase in thickness as we approach the Missouri river, and in the picturesque bluffs bordering the bottoms adjacent the river, it attains its maximum development, presenting a thickness of from two hundred to three hundred feet. In the intermediate country it everywhere envelopes the surface, forming the bulk of the uplands between the watercourses, and in which is moulded the prominent topographical features of the region. Terrace formations are rarely met with in this deposit. In the valley of Soldier river, in Harrison county, however, some of the finest examples of terracing are met, which are apparently entirely composed of the peculiar Bluff Deposit. But there is one fact worthy of note in this connection. In the valleys of the South Raccoon and Brushy Fork, along whose lower courses true gravel terraces are found, as throughout the Drift region of eastern Iowa, the moment we gain the region in which the Bluff Deposit occurs, we lose sight of the terraces

which are concealed beneath the superimposed deposit, which manifestly owes its origin to a later date than that to which the terraces belong.

The annexed profile presents a view of the relative sequence of the Post-tertiary deposits as they appear in this district, and as they are interpreted from the observations made herein:

FIG. 44



The obliquely-lined space indicates the Glacial Deposit, and the dotted space represents the modified Drift or Gravel Deposit, while to the left, the space left in blank shows the Bluff Deposit. The profile gives approximately the contour of the country between the Des Moines and Missouri rivers along a line running nearly due west from Boonsboro. The watershed is about fifteen hundred feet above the level of the sea, and the difference in the levels of the Des Moines and Missouri rivers is about one hundred and seventy-five feet, the latter being the highest, or four hundred and eighty-five feet lower than the main divide.

The Bluff Deposit has the appearance of a light colored clay; while in reality, analysis shows it consists of a homogeneous mass of exceedingly finely comminuted silicious material, with a rather large admixture of calcareous matter and but a comparatively small per cent of argillaceous material. It is remarkable for the uniformity with which its component parts are distributed, being the same and apparently in nearly the same proportion throughout its whole depth. The soil derived from this deposit is one of the most remarkable in the West. Its fertility is unquestionable, and for the production of all the small grains and corn it is equal to the best loam-soil of eastern Iowa; while, at the

same time, it possesses the advantage of being susceptible of cultivation under circumstances which would render a clayey soil untillable. This is probably due to its porosity, and the consequent absorption of moisture from the atmosphere in seasons of drought, at the same time facilitating the draining of excessive surplus water in seasons of prolonged rains.

In the region of the Drift the soil is mainly a black, gravelly loam. But there is usually a strip of country lying in the uplands between the watercourses, where we find a heavier and more soggy soil. In these belts, also, ponds are prevalent, as may be seen all along the upland, a few miles west of the Des Moines river, in the counties of Boone and Webster, and in which, indeed, the lakes in Calhoun county are situated. The origin of the soil, the ponds, and the lakes, is referable to the character of the immediately subjacent deposit which is here found to be the blue glacial clays—a deposit quite impervious to water—which comes to the surface over considerable areas. The distribution of the gravel bed in the uplands between the Racoon and Des Moines rivers, is well shown in the profile (Fig. 44), where they are seen but lightly to cover the middle portion of the divide, but gradually increase in thickness on approaching the margins overlooking the valley of the Des Moines on the one hand, and the former stream on the other. The country being generally level, the drainage is very imperfectly performed, compared with that in sections where the subsoil consists of the loose materials of the modified drift. And the same is true of the Bluff Deposit; no ponds are there met with, and no wet lands exist, save in the lower bottoms along the larger streams, and in the Missouri bottoms in the early spring months, when the ground is soaked from the melting of the snows and the frequent showers that take place in that season.

Another interesting feature is observed in connection with the soils in the eastern portion of the district, and in the counties west of the Des Moines, in the region occupied by the coal-measures, and in which the Drift Deposits are but

sparingly distributed, compared to the development of these deposits in the region farther north. The comparative paucity of the Drift in this section, which includes, so far as our observations have extended, the counties of Warren, Lucas, Monroe, Davis, and Appanoose, seems to furnish satisfactory explanation of the origin of the argillaceous soil occurring over considerable tracts in the uplands in those counties. We are forcibly struck with the appearance of these tracts in passing from the northern counties southward, or from the loamy soils of the Drift region, to the argillaceous soil locally found in the southern coal counties. The clay soil is of a light color, somewhat recalling the Bluff soil in appearance, but differing widely from that deposit in composition, and is very fertile and durable; but it is not as susceptible of tillage, in extreme wet or dry seasons, as are the loamy soils of the Drift. It is probably directly derived from the disintegration of the shales of the subjacent coal-measures.

The accompanying ideal section (Fig. 45), illustrates the distribution of the superficial deposits, and their relation to the underlying coal-measure strata at many localities in this part of the State.

FIG. 45.



The gravel deposit (*b*) always flanks the uplands, becoming thinner as we approach the crest of the divides, so that the coal-measure shales may, and doubtless do, rise quite to the surface at many points along the middle portion of the uplands. By the wash of the higher points in the course of the great interval which intervenes between the present and the recession of the waters, following the Drift epoch, the fine argillaceous material was gradually distributed over the remnant of the Drift Deposits upon the flanks of the uplands

thus producing a well-marked soil which does not at all partake of the Drift in its origin. Indeed the existence of the Drift may be pretty satisfactorily determined by examining into the character of the natural drainage of the surface. The Drift, wherever present, forms a porous subsoil, highly serviceable in securing the drainage of the surface waters; on the contrary, in situations where the subsoil is wholly composed of the argillaceous material derived from the coal-measure shales, the land is less perfectly drained, and in consequence the soil is of a cold and less tractable nature. Wherever the subjacent coal-measure shales are arenaceous in character, there a sandy soil is produced in the same manner as in the case of the clay soil. In some localities indeed, these sandy tracts are met with under circumstances which seem to be explicable in no other manner.

5. CRETACEOUS.

The deposits referable to the Cretaceous age, pertain to the lower group of which three formations are recognized within the borders of Iowa. In the extreme southeast portion of the area occupied by the rocks of this period, we find the lowermost, or Nishnabotany sandstones. These appear in the region of the Raccoon rivers, in Guthrie and Carroll, and probably certain sandstone deposits in Greene and Calhoun counties, belong to the same series. These deposits, which are described in detail in the geology of the counties in which they outcrop, attain a thickness probably not far from one hundred and fifty feet. Indeed, we have at single localities vertical exposures of one hundred feet. In the country to the northwest, however, the Cretaceous, as well as all the older rock-formations, are lost to view, and we do not again meet with these deposits until gaining the extreme northwestern corner of the district, where, in the county of Woodbury, a series of shales and sandstones in alternating beds outcrop in the base of the bluffs bordering upon the Missouri, which show about one

hundred feet thickness of what Dr. White has termed the *Woodbury formation*. This formation is doubtless considerably thicker, but its appearance to the southward, in the region intermediate between the exposures of the Nishnabotany sandstone and the localities in Woodbury county, is unknown. But it is presumed that a thickness of at most one hundred feet will fill the hiatus existing between the extreme outcrops of the two lower formations of the group. Resting upon the Woodbury sandstones and shales, in the northwest part of Woodbury county, a thickness of some fifty feet of calcareous shale, and above chalky and shelly limestone, is met with which is designated as the chalky formation or *Inoceramus* beds, from the prevalence in these beds of the fossil shell called *Inoceramus problematicus*. These upper beds, both lithologically and palæontologically offer a more striking contrast to the two lower formations than that which distinguishes those formations from one another. We have here a sudden introduction of calcareous matter, with a fauna apparently quite distinct from that found in either of the preceding formations, whose characteristics in each case are given in the detailed geology of Woodbury county.

The lower, or Nishnabotany sandstone formation is composed of incoherent sands and gravel layers, with now and then beds of soft clays, in every respect presenting the appearance of a littoral deposit. Amongst the pebbles are fragments of silicified corals of Devonian or Silurian age, and in a ferruginous sandstone deposit, described by Dr. White, in Montgomery county, a few leaves have been found which are identical with those found in the Woodbury formation. Indeed, the affinity between these two formations is far more strongly suggested than that existing between them and the succeeding "*Inoceramus* beds." The principal fossils found in the Woodbury formation are the leaves of Angiosperms, a small Fern, a species or two of *Gasteropoda* and *Lamellibranchiata*, and the remains of Ganoid fishes; the latter differing from anything thus far

known from the chalky beds, which are characterized by the remains of Teliosts or common fishes, and sharks, and by the abundant prevalence of *Inocerami* and an *Ostrea*, *Ammonites*, and the minute exuviae of a Rhizopod.

The maximum thickness of the Cretaceous strata exposed in Woodbury county is probably not less than two hundred feet. It is further believed that all the strata here exhibited occupy a position above the sandstones which outcrop on the southeastern border of the Cretaceous area, in Guthrie county, which add at the least one hundred feet to the Woodbury county section, making the actually known thickness of the Lower Cretaceous group not less than three hundred feet in Iowa. The economic value of these deposits consists mainly in the building material they afford. Thin bands of lignite occur in both the lower and middle beds, but there are no indications of more extensive deposits existing in the series within the borders of the State.

6. COAL-MEASURES.

In the eastern portion of the district the coal-measure series outcrop over a considerable area, where they present characteristic features peculiar to them. The Lower and Middle measures in that region are well displayed, the latter of which has been described in detail in the chapter on the Middle coal-measures. As we approach the Great Watershed these formations disappear, and thence we meet with no deposits of older age than the Post-tertiary, until gaining the valley of the Boyer a few miles above its junction with the Missouri valley, where a few limited outcroppings of Upper coal strata are found, which form the most northerly exposures of this formation in the State. These exposures occur on a line but little north of due west of the border outcrop of the formation in Guthrie county, and probably a slightly curved line, whose convexity is turned to the north, would describe the northern border limits of the formation in the State.

Of the distribution of the Middle and Lower measures in

the country to the west of the great divide, we have no means of arriving even at an approximate knowledge, since these deposits are lost to view as soon as we pass beyond the North Raccoon and Middle Raccoon rivers to the westward. How far to the northward of the northern border outcrop of the Upper coal formation these deposits may extend it has been impossible to ascertain, owing to the entire surface in the region west of the watershed being deeply enveloped in the superficial deposits of the Post-tertiary period. A line drawn from Fort Dodge in a southwesterly direction, passing through Calhoun and Greene counties, to the northwest corner of Guthrie county will conform very nearly to the known western limits of the Lower or productive measures in this district. The Middle coal formation embraces a large portion of the area of Guthrie and Dallas counties, outcropping over a belt of country from eight to fifteen miles in width, which is suddenly lost to view on approaching the watershed divide in the western portion of the first named county, and to the southeastward forming a similar belt, which pursues a course nearly parallel with the Des Moines river to the southern boundary of the State.

7. DALLAS COUNTY.

Dallas county is bounded on the north by Boone and Greene counties, on the east by Polk, west by Guthrie, and on the south by Madison county. The county comprises sixteen townships, or an area of about 576 square miles.

General Surface Features—Drainage. The Raccoon river and its tributaries drain the larger portion of the county with the exception of the northeastern townships, which are drained by Beaver creek, an affluent of the Des Moines. The three principal branches of the Raccoon—the North, Middle, and South Raccoon rivers—have their confluence in this county, the larger or North Raccoon entering the county near its northwestern corner, and flowing thence southeasterly, it joins the main stream on the southern border

about in the middle of the county. From this point we ascend the South Raccoon in a westerly direction to the western border, where it receives the Middle Raccoon, which latter stream, however, has but a few miles of its course within the county. West of the North Raccoon, Panther and Mosquito creeks are important drainage channels, while to the south of the South Raccoon, Bulger and Bear creeks are the most important of the numerous small watercourses in that quarter.

The *surface configuration* presents somewhat varied aspects in different portions of the county, which are due in great measure to the nature of the underlying coal-measure formations. The larger streams have eroded their beds to a depth of from one hundred to two hundred feet below the general upland level, producing narrow valleys bordered by more or less abrupt acclivities. The northern portion of the county is gently undulating, and its surface tolerably well drained. To the west of the North Raccoon the surface descends into a broad, shallow depression which corresponds to a shallow, synclinal basin that exists in the coal-measure strata in this section of the county. East of the North Raccoon the country is high and level, and mainly watered by small streams which flow directly into the Raccoon and Des Moines rivers, and whose valleys are cut into the deposits belonging to the Middle coal-measures. The narrow strip of territory lying to the south of the Raccoon and the South Fork, rapidly rises in the divide between the Raccoons and North river, which has its culmination within Madison county but little beyond the southern border of Dallas, embracing a tract much more broken in its surface features than the country to the northward.

The soil of the uplands is usually black loam. In the valleys, there is greater proportion of sand, and upon the terraces or second bottoms, we find a warm gravelly soil, as is usual in similar situations throughout this region. The forests are almost wholly confined to the valleys, and are of sufficient extent for all the ordinary wants of the county for

years to come. The more common kinds of trees are the black-walnut, soft maple, several varieties of oaks, elm, ash, etc. Fruit growing has hardly begun to receive that attention which it promises so well to remunerate. The culture of the grape, so far as it has been experimented upon, also gives every indication of proving successful. The fine large orchard of young apple and pear trees, and vines, on Mr. Frank Graham's estate, near Adel, compares favorably with any we have seen in the State. There is no reason to believe but that fruit-growing will soon become an important source of wealth to the county. Artificial groves thrive in all situations, as well upon the uplands as in the valleys; and already the country is being embellished with groves of trees in every direction, contributing a pleasing feature to the prairie landscape.

Springs issue from the gravel beds along the bluffs, and in the ravines, at frequent intervals. Wells of water are easily obtained in most places at a moderate depth beneath the surface; they are almost invariably excavated into the gravel beds immediately overlying the impervious Drift clays, which form natural reservoirs for the retention of the waters which are filtered through the bed of loose materials above.

Geology. The geological formations which occur in Dallas county belong to the Post-tertiary and Coal-measure periods.

Post-tertiary. The Drift is generally spread over the whole county and is of variable thickness, estimated at from ten to fifty feet. On the North Raccoon, above Adel, the bluffs in many places are largely composed of these deposits; but along the streams to the southward, the Drift has been extensively denuded, and here its minimum thickness is found. The Drift is made up of blue clays and gravel beds—the former representing the original glacial deposits; and besides the boulders and pebbles, and “sand pockets” which are distributed through its mass, fragments of coniferous wood are not of unfrequent occurrence. Frequently in excavating for water, these “old forest beds” are encountered, and the

trunks of quite large trees have been discovered in a very perfect state of preservation. In the neighborhood of Sugar creek, east of Adel, large more or less abraded blocks of light-colored, compact limestone are found scattered over the surface, or more or less deeply imbedded in the gravel or clays of the underlying Drift Deposits, which have excited no small degree of wonderment, and have been the objects of much speculation as to their origin. But that they were derived from the Drift, there can be no doubt; and, further, that their origin was far to the northward, is proven by the few obscure organizations preserved in their mass, which show them to be of Lower Silurian age—probably the Trenton limestone—and were transported from their native ledges in the north by the same agencies which brought down from the same direction the immense amount of detrital materials composing so considerable a proportion of the superficial deposits of eastern and central Iowa. The fact that the limestone boulders are apparently more numerous in this section than in the country northward in this and adjacent counties, is probably owing to the much greater degree of denudation to which the drift was subjected along the lower reaches of the Raccoon in the process of the erosion and deepening of its valleys, which swept away the larger portion of the finer materials of which these deposits were in part composed, leaving behind only the boulders and coarser materials, as they are now found.

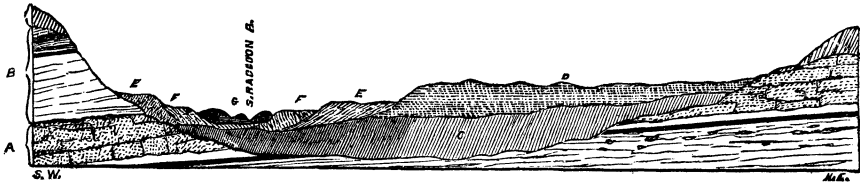
The loose materials form a considerable though unevenly distributed member of the Drift, and one that is co-extensive with the unmodified deposit in the uplands. In the valleys, these deposits have been subjected to still further modifications by currents of water confined in definite channels, which have produced those varied phenomena we find displayed in the terrace formations that border the larger watercourses.

In the vicinity of Redfield, the valley of the South Raccoon is beautifully terraced, there being three or four distinct benches besides the interval lands which are still subject to

periodic overflow. The annexed profile was taken above the confluence of the Middle Raccoon, and furnishes a fine example of terraces in this region:

FIG. 46.

Profile of the Valley of the South Raccoon, above the confluence of the Middle Raccoon.



a, Lower coal-measures; *b*, Middle coal-measures; *c*, Drift; *d*, *e*, *f*, Terraces; *g*, present flood-plain, or intervale.

The highest bench, (*d*) has an elevation of about forty feet above the South Raccoon, forming a level plain about half a mile wide. Resting upon this terrace are several quite symmetrical oblong mounds from eight to ten feet in height; they are composed of gravel, and do not differ in this respect from the composition of the terrace upon which they rest. It has been suggested that these mounds were the work of the aboriginal inhabitants; on the other hand, there is quite as good reason to suppose they are of natural origin—being nothing more than gravel bars which were formed when the waters of the river occupied a higher level, and this bench formed the flood-plain. Below this terrace there are two others, whose elevations are respectively twenty feet and ten to fifteen feet above the river. The higher and better defined benches are composed of coarse gravel and sand; the lower or intervale bottoms are principally made up of sand and the finer sediments deposited by the annual freshets. The village of Redfield owes much of the beauty of its situation to this set of terraces which occupy the wide recess formed by the junction of the two streams in this vicinity.

In the valley of the North Raccoon, at Adel, a similar

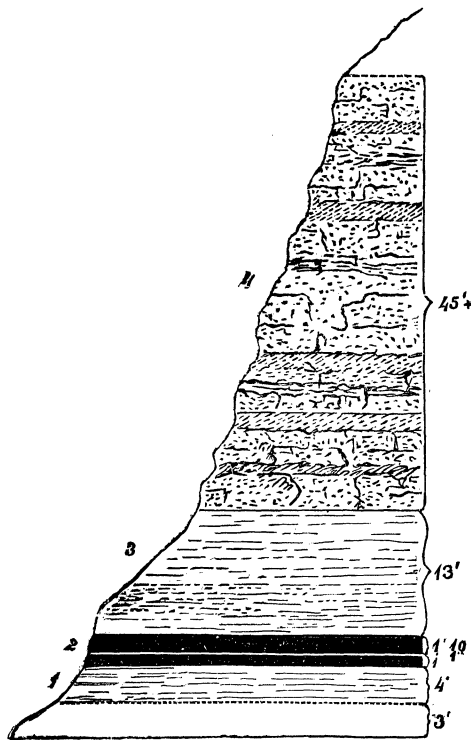
series of terraces are found, though less regular and beautifully defined than those at Redfield. Adel is built upon the higher bench, which is twenty to thirty feet above the river, and corresponds in the nature of the materials of which it is composed, with the terraces above mentioned. These formations are again met with on the northern border of the county, the valley here presenting three or four benches, which are remarkable for their graceful conformation. The intervalles or alluvial lands are of limited extent, being wholly confined to the narrow belt immediately bordering the streams, and are mainly important for the forest growths they support.

Coal-Measures. The only consolidated strata found in Dallas county, pertain to the coal-measures, which underlie its whole area. That portion of these strata which are seen at the surface, comprise the upper beds of the Lower coal-formation, the entire thickness of the Middle formation, with the lower beds of the Upper coal-measures, which latter appear only in the southwest part of the county.

Lower Coal Formation. This formation occupies the larger portion of the northern half of the county, and a slight anticlinal fold or undulation brings its upper beds to view in the valley of the South Raccoon, in the southwestern corner of the county, near Redfield, where it outcrops over a limited area, partially hemmed in by the succeeding strata of the Middle coal-measures. This area may possibly prove to be an arm running southward along the crest of a gentle anticlinal undulation from the main area of the formation, forming a bay-like recess corresponding to similar recessions in the border outcrops of the Middle coal-measures in the counties to the southeastward.

A short distance below Redfield, a bed of coal nearly three feet thick crops-out in the banks of the Middle Raccoon, on lands of J. Ward Redfield, Esq., section 9, township 78, range 29, where the following section was measured:

FIG. 47.

Section at Redfield's Coal Mine near Redfield.

No. 4. Heavy bedded, yellow to dark brown, fine grained sandstone, with shaly and obliquely laminated layers, 45 feet, more or less.

No. 3. Light-blue, partially indurated shales, slightly arenaceous in the middle, 13 feet.

No. 2. Coal, $2\frac{1}{2}$ feet to 3 feet. This bed is separated into two layers by a thin seam of clay, not above an inch thick. The upper layer of coal is the thickest. The clay parting contains very obscure vegetable remains.

No. 1. Blue, slightly gritty clays, highly charged with persulphate of iron, and containing few imperfect plant remains, exposed to water level. 7 feet.

The coal-bed shown in the above section is doubtless the equivalent of the bed which is now being so extensively mined at Des Moines, only differing from the Des Moines

coal in having a less number of clay partings. At present the bed is mined on a limited scale; its product is of fair average quality, and it will become a valuable deposit when there shall be a greater demand for mineral fuel in this section. The shales and sandstone overlying the coal are best seen in the bluff a short distance above the mine, and in the right bank of the river at the "hanging rock" the sandstone forms a picturesque mural escarpment above forty-five feet in height. This bed, however, rapidly disappears beneath the river to the northwestward, as it does also on the South Raccoon below Redfield. At Newport mills, on the latter stream, half a mile southeastward of Redfield's mine, some ten feet of micaceous, more or less laminated, sandstone is exposed, the lower portion of which contains large lenticular concretions which recall to mind similar deposits underlying the coal-bed at Des Moines. Should this identity exist, the coal must be found in the adjacent bluffs on the right side of the river, where it has not been denuded by the erosion of the valley, and also on the north side of the valley it may possibly be reached by shafting.

Only one or two unimportant exposures of Lower coal strata are at present known in the valley of the North Raccoon within the borders of Dallas county. In section 16, township 81, range 28, a thin seam of coal has been found on a branch near Mr. J. H. Roberts. In the left bank of the river, in section 17, township 81, range 28, a similar exposure was examined on lands of Mr. Hiram Harper, where a four-inch coal seam occurs. A heavier bed is said to outcrop in the bed of the river at this locality, fragments of coal having been washed out and deposited upon the sand-bars by the freshets.

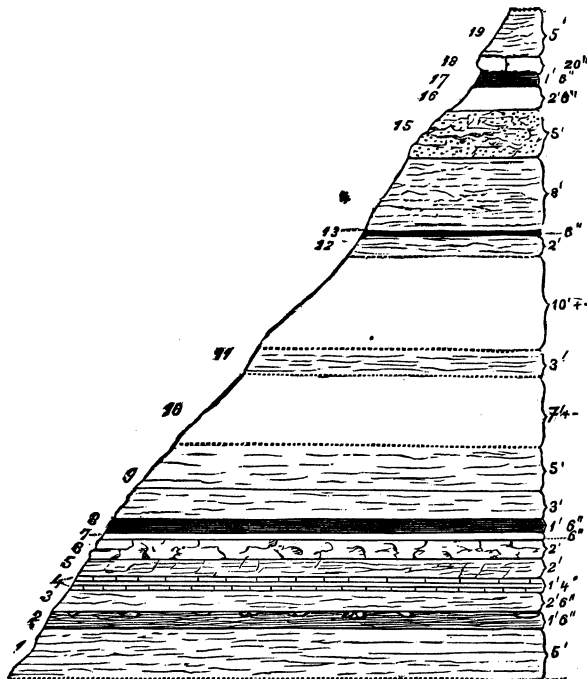
It is not improbable that other and workable beds of coal may be found in this part of the county. But owing to the soft nature of the strata of this formation, the slopes have been smoothed down, and the coal-beds, if they really exist here, are concealed beneath a detrital accumulation partly derived from the disintegrated subjacent strata and

the Drift, so that we are obliged to rely in almost all cases on such meagre exposures as those last mentioned for the means of studying the structure of the productive measures, not only in this particular section, but almost throughout the entire extent of country occupied by the Lower coal-measures.

Middle Coal Formation. This formation probably embraces in its outcrops nearly half the area of the county. Ascending the valley of the Raccoon from its confluence with the Des Moines, at the city of Des Moines, the strata dip gradually to the westward, which carries down the lower member of the Middle coal-measure formation to a level but little above the river at Rocky ford, on the eastern border of Dallas county. At this locality, (section 26, township 78,

FIG. 48.

Section near Mr. Colton's.



range 26), the uppermost layers of the lower division appear in the right bank of the river, where the fossiliferous limestone layers overlying the Panora coal present their usual lithological and palæontological characteristics. The exposure is capped by a four-foot bed of sandstone which forms the upper bed of this division. The Panora coal does not appear above the river level, unless it is represented by the dark pyritiferous shales at the water's edge in the base of the exposure. Above Rocky ford, the next exposures of rock are found in the bluffs bordering the south side of the valley in sections 27 and 26, township 78, range 27, near Mr. Colton's, and but a short distance above the Chicago, Rock Island, and Pacific Railroad bridge. At this locality the middle division has almost a complete representation, and is capped by the lower member of the upper division, as shown in the preceding section:

No. 19. Yellow shales, exposed 5 feet.

No. 18. Heavy-bedded, impure, fragmentary limestone, 20 inches. Contains two or three species of Polyzoa, *Athyris subtilita*, *Spiriferina Kentuckensis*, *Martinia planoconvexa*, *Hemipronites crassus*, (?), *Chonetes mesoloba*, *C. mucronata*, *Productus longispinus*, *Bellerophon*.

No. 17. Black, carbonaceous shales, 18 inches. Lower carbonaceous horizon of the upper division.

No. 16. Light-colored clays, $2\frac{1}{2}$ feet.

No. 15. Light-red sandstone, shaly above, 5 feet, with *Sigillaria*.

No. 14. Yellow, arenaceous clays, 5 to 8 feet.

No. 13. Marshall coal, 6 inches.

No. 12. Bluish-yellow clays, exposed 2 feet, but probably occupying much of the unexposed slope below.

No. 11. Blue clays exposed, 3 feet.

No. 10. Unexposed, about 7 feet.

No. 9. Blue and reddish shales, 8 feet.

No. 8. Bituminous shales, $1\frac{1}{2}$ feet, with fucoid-like markings. Equivalent to bed 29, General Section of Middle coal-measures.

No. 7. Blue shales, 6 inches. Contains *Productus muricatus*, *Chonetes mesoloba*, *Hemipronites crassus*.

No. 6. Irregularly bedded, fragmentary, impure limestone, 2 feet.

No. 5. Partially indurated, blue clays, 2 feet.

No. 4. Light-colored, argillaceous, indurated bands, 16 inches, with *Hemipronites* and *Athyris*.

No. 3. Gray and blue shales, $2\frac{1}{2}$ feet.

No. 2. Dark clays, with concretionary band at top, $1\frac{1}{2}$ feet.

No. 1. Blue, slightly gritty, shales, exposed 5 feet, and above the level of the river 18 feet.

The upper beds of the section are well-exposed just above the railroad track in the bluff on the south side of the river, on section 26. The large masses of limestone in the river bank below the track belong to bed No. 18, having been displaced by a land-slide. The Marshall coal, No. 13, with all the lower beds included, is finely displayed in a ravine a few hundred yards west of the former exposure, in section 27, where a thickness of about seventy feet of strata is exposed. The coal is here two to six inches thick, and it has furnished small quantities of coal for blacksmith's use; the bed is too thin for profitable working, however superior its quality. The sandstone, No. 15, limits the upper part of the middle division, and is overlaid by the lower black shales, and its accompanying limestone of the upper division, which is always a reliable and easily recognized horizon of this formation.

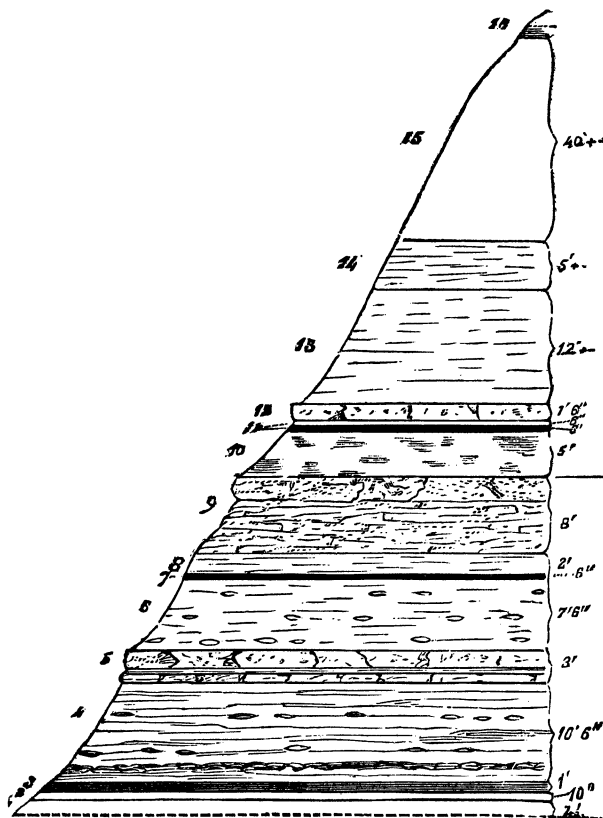
In the bed of the river, half a mile west of the Boone station, ledges of brown and gray, compact, thin-bedded, micaceous sandstones, with ripple-marked surfaces, crop-out, forming a rapid-obstruction in the river. This bed may be referable to the beds of passage between the middle and lower divisions.

In the vicinity of De Soto, almost the same series of strata are met with as were described in the section near Mr. Colton's, five miles to the eastward. At Van Meter's mill, about two miles north of the station, the Marshall coal, here a seam not above six inches thick, outcrops in the left bank of the South Raccoon, where a fine section is presented of the accompanying strata, including some twenty-four feet of shales inclosing a limestone layer, between the coal and the bed of the stream; and also showing the sandstone at the top of the middle division. On Bulger creek, in the immediate vicinity of De Soto, the upper layers of the last mentioned

sandstone are seen in the bed of the creek, supporting some eighteen feet thickness of shales, including the lower carbonaceous horizon of the upper division. The accompanying section presents a general view of the strata exposed in this neighborhood:

FIG. 49.

Section in the vicinity of De Soto.



No. 16. In the top of Miller's hill, an imperfectly exposed thin bedded, gray limestone is seen, containing *Fusulina cylindrica*, crinoid stems, *Polysphaera*, *Martinia lineatus*, *Athyris subtilita*, *Hemipronites crassus*, and undetermined species of Gasteropoda.

No. 15. Unexposed, probably made up of shales, 40 feet.

No. 14. Red shales, exposed, 5 feet.

No. 13. Yellow shales, in places slightly arenaceous with indurated ferruginous bands, 10 to 15 feet.

No. 12. Rather compact, even bedded, grayish blue earthy limestone, weathers to a soft, dingy yellow, 2 feet. The following fossils were observed in this bed: *Fusulina*, crinoid stems, *Hemipronites crassus*, *Chonetes mesoloba*, *Productus longispinus*, *Athyris subtilita*, *Spirifer cameratus*, *Martinia planoconvexa*, *Retzia punctilifera*, *Bellerophon crassus* (?).

No. 11. Black carbonaceous shales, separated from the cap-rock by a thin layer of light clay, 12 to 18 inches. Contains *Petrodus* and spines.

No. 10. Mottled shales, 5 feet.

No. 9. Soft, brown, laminated sandstone, with firmer layer above, and shaly partings below, 8 feet. Imperfect remains of plants—*Neuropteris*, *Sigillaria*.

No. 8. Yellowish, slightly arenaceous shales, 2 feet.

No. 7. Marshall coal—impure coal, 6 inches.

No. 6. Yellow, slightly gritty shales, with nodular bands, $7\frac{1}{2}$ feet.

No. 5. Light bluish, fragmentary, earthy limestone, in two layers with marly clay parting, 3 feet. These layers are usually less intimately associated, though they still preserve their palæontological characteristics. The lower layer contains a predominance of *Productus æquicostatus*, while *P. muricatus* is most abundant in the upper layer. Besides those species, the following were obtained from these layers: Crinoid stems, *Chonetes mesoloba*, *C. mucronata*, *Hemipronites crassus*, *Orthis carbonaria*, *Athyris subtilita*, *Martinia planoconvexa*, *M. lineatus*, *Spiriferina Kentuckensis*, *Rhynchonella Uta*, *Pleurotomaria*.

No. 4. Variegated shales with occasional nodular and indurated bands, $10\frac{1}{2}$ feet. In the lower portion of the bed the following species of fossils were found: *Lingula* ———, *Discina Missouriensis*, *Athyris subtilita*, *Hemipronites crassus*, *Chonetes mesoloba*, *Productus muricatus*, *P. æquicostatus*, *Martinia planoconvexa*, *Pernopecten*, (sp. ?), *Orthoceras* ———, *Petrodus* and spines, and Ganoid scales, same as in bed No. 3.

No. 5. Black carbonaceous shales, 1 foot. Contains *Lingula* ———, *Rhynchonella Uta*, *Spiriferina Kentuckensis*, *Productus muricatus*, *Petrodus* and spines, small rhombic scales of Ganoids, probably belonging to the genus *Palæoniscus*.

No. 2. Gray indurated, calcareous shales, 6 inches. Contains *Athyris subtilita*, *Hemipronites crassus*, *Chonetes mesoloba*, *Productus æquicostatus*, *P. muricatus*, *Myalina* ———, *Edmondia*, *Pleurotomaria*.

No. 1. Blue shales, with minute concretions, exposed above water level 2 feet.

Numbers one to nine inclusive, are seen in the left bank of the South Raccoon, just below Van Meter's mills; the remainder of the section is best displayed on the Bulger, at De Soto, also on a small branch in the southwest quarter of section 18, township 78, range 27, on Mr. Miller's farm, and

in a ravine opposite his house. Bed number sixteen outcrops high in the hill-side on the same quarter-section, and probably belongs to the upper limestone horizon of the upper division—bed number forty, of general section of Middle coal-measures. The strata in this neighborhood have a slight southerly or southeasterly inclination which, as we ascend the valley of the Bulger, carries them beneath the Upper coal-measures, the limestones of which appear in the higher upland declivities on the borders of Dallas and Madison counties.

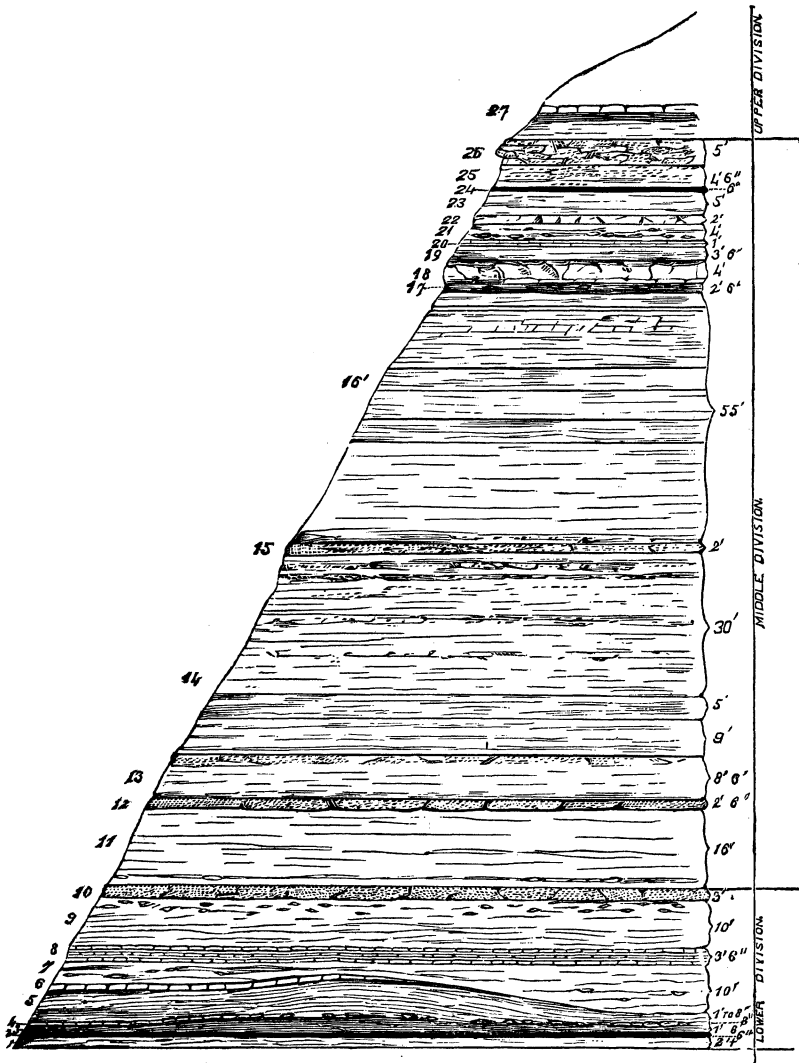
To the westward of De Soto, the strata continue to rise, bringing to view successively the lower division of the Middle coal and the upper beds of the Lower coal-measures, which latter outcrops in the valley, in the vicinity of Redfield, as has been already described. From this locality, the strata are observed to have a very considerable westerly dip, which in the distance of one or two miles above the confluence of the Middle and South Raccoon rivers, carries the Lower coal-measures beneath the level of both streams, and again the middle formation appears in the valley-sides, presenting successively its three divisions as we ascend either stream to the westward.

Two miles northwest of Redfield, in the vicinity of Mr. Thomas Fee's, the Panora coal outcrops in the south side of the valley of Mosquito creek, (sections 34 and 27, township 79, range 29), on lands belonging to Messrs. Parker and Piatt. The coal at this locality is about six inches thick, its outcrop being thirty to thirty-eight feet above the Middle Raccoon. At Parker's mine, the coal and the strata with which it is immediately associated, differ, in no respect, from the normal condition presented by the horizon throughout the Middle coal region; but at Piatt's mine, two or three hundred yards east of the former, we find a remarkable thickening of the bituminous shales overlying the coal and the intercalation of a band of gray calcareous shale with fossils, besides, the cap-rock is represented by thin pyritiferous nodules, hardly recognizable as the same bed as

that seen at Parker's. The bed dips rapidly to the westward, and on gaining the Middle Raccoon, half a mile west of Parker's mine, the coal-bed disappears beneath the river level. In the southwest quarter of section 34, a limited

FIG. 50.

General Section on the Middle Raccoon above Mosquito Creek.



exposure of the upper fossiliferous earthy limestone layers of the lower division may be seen in the right margin of the river where they present their usual characteristics. Above this point, higher and higher strata are successively encountered, consisting of shales and arenaceous deposits pertaining to the two lower divisions of the formation, and which appear at frequent intervals in low bluffs on the north side of the stream. Near the Guthrie county line, about two miles southwestward of Parker's coal mine, the upper beds of the middle division are beautifully exhibited in a high bluff skirting the left bank of the river which gives a vertical exposure of above eighty feet. Near the top of the exposure, the Marshall coal—here a thin seam about six inches thick—outcrops beneath a thin ledge of sandstone, and immediately above the sandstone, the lower carbonaceous horizon of the upper division appears, which is the highest bed found at this locality.

From the data furnished by the examination of the exposures mentioned in brief above, the preceding general section has been constructed, which exhibits the aggregate thickness of strata between Mosquito creek and Huggin's branch, along a northeast and southwest line about two miles in length.

No. 27. Black shale, overlaid by impure limestone band, imperfectly exposed. Lower carbonaceous horizon of the upper-division.

No. 26. Rather compact, grayish yellow, shaly sandstone, 5 feet.

No. 25. Yellow, laminated, arenaceous clays, $4\frac{1}{2}$ feet.

No. 24. Marshall coal—impure coal, 6 inches.

No. 23. Yellow and bluish shales, 5 feet.

No. 22. Rather compact, heavy bedded, buff, earthy limestone, 2 feet.

No. 21. Bluish clays, with thin calcareous layers and nodular band above, 4 feet. Contains *Productus muricatus*, *Athyris subtilita*, etc.

No. 20. Light-bluish, earthy limestone, in two layers; lower one compact, with abundance of *Productus equicostatus*; upper layer shaly, with *Productus muricatus*, *P. semireticulatus*, (?), *Chonetes mesoloba*, *Athyris subtilita*.

No. 19. Dark-blue and red clays, $3\frac{1}{2}$ feet.

No. 18. Fragmentary, yellow, impure limestone, decomposed above and below, 4 feet.

- No. 17. Dark-blue clays, $2\frac{1}{2}$ feet. Contains *Petrodus* and spines.
- No. 16. Alternating layers of blue and reddish shales, more or less indurated and in the upper part micaceous, with thin seam of calcareous shale and irregular band of small concretions, 55 feet.
- No. 15. Gray, shaly, micaceous sandstone, 2 feet.
- No. 14. Alternating layers of red, blue, and yellowish-gray shales, slightly gritty and micaceous above, about 44 feet.
- No. 13. Blue and gray clays, arenaceous above, with band of dark, coarsely gritty shales at base, $8\frac{1}{2}$ feet.
- No. 12. Light-gray, soft, heavy-bedded sandstone, $2\frac{1}{2}$ feet.
- No. 11. Dark-blue shales, becoming more or less arenaceous above, about 16 feet. At the base a blue sandy shale occurs, and immediately above is a thin band of clay containing great numbers of *Aviculopecten rectilateraria*.
- No. 10. Soft, reddish and gray shaly sandstone, 3 feet. This bed forms the uppermost layer of the lower division.
- No. 9. Red clays overlaid by blue clays, with nodules and slightly arenaceous above, 10 feet.
- No. 8. Argillaceous limestone, consisting of four layers with shaly partings, 3 to 4 feet. The lower layers contain great abundance of *Productus muricatus*; also, *Chonetes mesoloba*, *Athyris subtilita*, crinoid stems. The middle layer is charged with *Martinia planoconvexa*, besides *spirifer cameratus*, *Athyris subtilita*, *Rhynchonella Uta*, *Hemipronites crassus*, *Productus muricatus*. The upper layer is a very compact gray limestone, with numbers of a minute species of Gasteropod, and an *Aviculopecten*.
- No. 7. Light and gray, fine gritty shales, 5 to 10 feet.
- No. 6. Dark-gray, indurated calcareous shales, 6 to 10 inches. This is an intercalated layer, seen at Piatt's coal mine, on Mosquito creek, where it is charged with the following fossils: *Productus muricatus*, *P. æquicostatus*, *Hemipronites crassus*, *Athyris subtilita*.
- No. 5. Dark-blue or brown shales, sometimes with layer of bluish-yellow sandy clays at top, 1 to 8 feet. Seen at Piatt's coal-bank.
- No. 4. Bluish, impure, pyritiferous limestone, in places nodular, and sometimes wanting, 8 inches. Contains *Productus muricatus*, *Chonetes mesoloba*, *Martinia planoconvexa*, *Athyris subtilita*, *Rhynchonella Uta*, *Bellerophon*, *Orthoceras*.
- No. 3. Black shales, 18 inches to 3 feet.
- No. 2. Panora coal, 4 to 10 inches.
- No. 1. Light ash-colored and dark blue clays, with imperfect plant remains, 1 to 4 feet exposed.

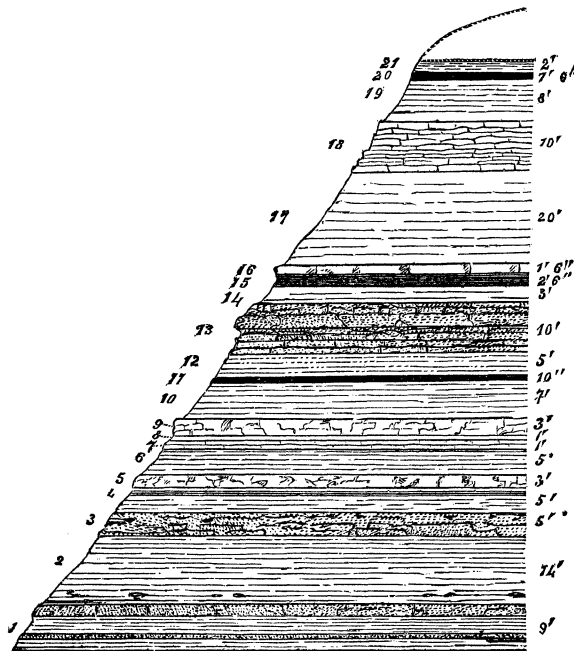
The lower beds of the above section are seen on Mosquito creek, at Parker's and Piatt's coal-mines. Those from No. 8 to 15 are well shown in the bluff exposures on the Middle Raccoon, above the mouth of Mosquito creek; and the remainder of the section is that which is presented in the high

bluff escarpment on the western border of the county. In a ravine in section 6, township 78, range 29, on the south side of the river, other exposures of these higher beds are found. High up the ravine, the sandstone and bituminous shales, Nos. 26 and 27, outcrops; and in the slope above, fragments of thin-bedded, yellow limestone occur, which probably belong to the bed underlying the Lonsdale coal. At the mouth of the ravine a ledge of shaly, micaceous sandstone outcrops, which is the equivalent of No. 15, of the preceding section.

At Duck's mills, in section 30, township 78, range 29, about two miles northwestward of the locality last mentioned, the middle and upper divisions of the formation are well shown in the bluff and ravine exposures on both sides of the Middle Raccoon. The Marshall coal appears in the bluffs above and below the mills; and near the head of a short ravine in the

FIG. 51.

Section at Duke's Mills, on the Middle Raccoon.



southeast quarter of section 30, the Lonsdale coal outcrops at an elevation of one hundred and five feet above the level of the river. This bed is here about eighteen inches thick, and the coal is said to be of superior quality; but as yet only a few bushels have been taken out, by stripping off the superincumbent earth. The preceding section presents a general view of the strata exposed at this locality, and shows the relation of the coal-beds to one another:

No. 21. Dark buff shales, exposed 2 feet. Contains: *Productus æquicostatus*, *Chonetes mesoloba*, *Hemipronites crassus*, (?), *Martinia planoconvexa*, *Pleurotomaria*, *Bellerophon carbonaria*, and other Gasteropoda, *Orthoceras*.

No. 20. Lonsdale coal, 18 inches.

No. 19. Ash-colored clays, 8 to 10 feet.

No. 18. Rather hard, shaly and sometimes heavy bedded buff limestone, 5 to 10 feet. *Zaphrentis*, crinoid stems, *Productus æquicostatus*, *Chonetes mesoloba*, *Hemipronites crassus*, *Mekella striatocostata*, *Athyris subtilita*, *Myalina subquadrata* (?) *Pinna* ———, *Aviculopecten* (sp. ?), *Pleurotomaria*, *Bellerophon crassus*.

No. 17. Blue, buff, and red clays, imperfectly exposed, 20 feet.

No. 16. Rather compact, bluish-gray, impure limestone, 1½ feet. *Cyathoxonia*, crinoid stems, *Polyzoa*, *Athyris subtilita*, *Martinia lineatus*, *M. planoconvexa*, *Hemipronites crassus*, *Chonetes mesoloba*, very small, *Productus longispinus*, *P. æquicostatus*, *Chonetes Verneuilianus*, *Phillipsia*.

No. 15. Black, fissile shales, 2½ feet. Contains *Petrodus*, and in the upper and less bituminous part, *Aviculopecten rectilateraria*.

No. 14. Ash-colored clays, about 3 feet.

No. 13. Soft, heavy-bedded, reddish sandstone with shaly partings, greatest thickness 10 feet. Contains *Sigillaria*.

No. 12. Yellow arenaceous shales, with imperfect impressions of ferns, about 5 feet.

No. 11. Marshall coal, 10 inches and less.

No. 10. Blue shales, 7 feet.

No. 9. Fragmentary, buff, impure limestone, 2 to 3 feet.

No. 8. Blue, marly clays, with same fossils as No. 7, 1 foot.

No. 7. Impure yellow limestone, in two layers, 1 foot. *Productus æquicostatus* is very abundant in the lower layer, while in the upper one, *P. muricatus* is equally common, besides *Chonetes mesoloba*, *Hemipronites crassus*, *Productus costatus*, *Athyris subtilita*, *Pleurotomaria*.

No. 6. Blue and reddish shales, 5 to 8 feet.

No. 5. Impure, buff, fragmentary limestone, decomposed above, 3 feet.

No. 4. Blue, gray, and chocolate-colored shales, with band of dark clay, near the top containing *Petrodus*, and *Martinia planoconvexa*.

No. 3. Rather compact, gray sandstone, overlaid by sandy shales with nodules in the upper part, 5 feet.

No. 2. Mottled blue and chocolate-colored shales, slightly micaceous, with nodular band at base, 14 feet.

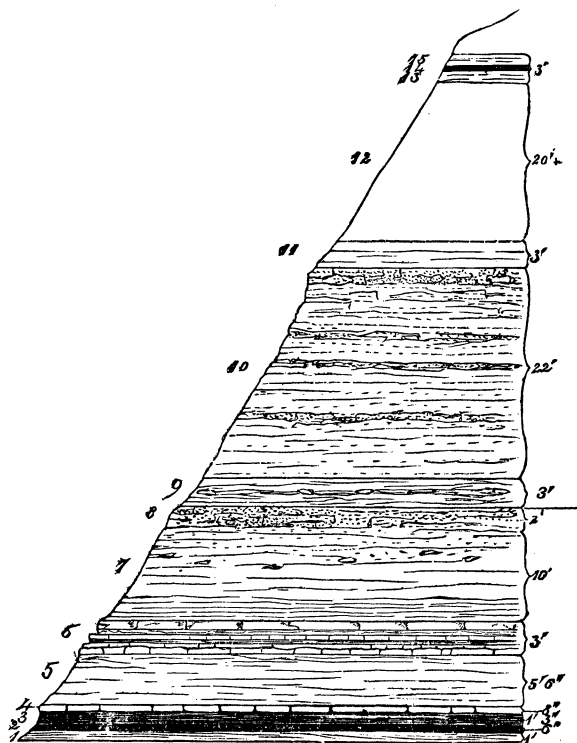
No. 1. Bluish, arenaceous shales, with irregular nodular bands, and more or less compact, gray, micaceous sandstone, 9 feet exposed. The upper sandstone layer contains *Productus æquicostatus*, *Hemipronites crassus*, Polyzoa, *Pleurotomaria*.

In the bluff exposure below the mills, an interesting example of the thinning out of an arenaceous deposit is seen in connection with No. 3 of the above section, which is entirely lost at the upper extremity of the exposure, the upper and lower argillaceous beds coming in immediate contact. The Marshall coal in the present exposure lies some sixty feet beneath the Lonsdale coal. It is too thin to be of economic value, being only about six inches thick. In the bluffs on the right bank of the river, above the mills, this bed attains the thickness of ten inches. It is here overlaid by the lower black shales and limestone band of the upper-division, with only a few feet of arenaceous shales intervening in the place usually occupied by the sandstone No. 13. Where this latter bed appears some portions of it may be found suitable for ordinary building purposes, but the principal supply of building stone is derived from the limestone bed No. 18. The lower limestone bands are worthless for such purposes.

Two miles southward of Redfield, in the bluffs on the south side of the South Raccoon river, (northwest quarter of section 16, township 78, range 29), at an elevation of about fifty-five feet above the stream, the Lacona coal and its accompanying overlying bands of fossiliferous earthy limestone are obscurely exposed, the coal being represented apparently by a thin layer of carbonaceous shales. Ascending the valley, two miles to the westward, in the northwest quarter of section 18, on lands of Mr. Peter Marshall, the same beds, including a thickness of above forty-five feet of overlying strata outcrop in the bluff on the right bank of the river, presenting the following section:

FIG. 52.

Section on the South Raccoon, near the Dallas and Guthrie county line.



- No. 15. Light blue clays, exposed 2 feet.
 No. 14. Marshall coal, 3 to 6 inches.
 No. 13. Light blue clays, with imperfect vegetable remains—ferns, &c., exposed 1 foot.
 No. 12. Unexposed; probably above 20 feet.
 No. 11. Blue, ferruginous shales, exposed 8 feet.
 No. 10. Finely laminated arenaceous clays, interstratified with shaly micaceous layers, and capped by a firmer layer of yellow sandstone, 22 feet.
 No. 9. Deep blue clay, enclosing pyritiferous nodules, 3 feet. *Aviculopecten rectilateraria* is very abundant in this bed, which also has a few obscurely preserved ferns.
 No. 8. Soft, yellow sandstone, 2 feet. Is irregular and sometimes its place is occupied by the upper arenaceous portion of No. 7.
 No. 7. Mottled reddish and blue clays, slightly arenaceous above, with nodules, 10 feet.

No. 6. Earthy limestone with shaly partings separating the bed into three layers, 3 feet. The lower layer is crowded with *Productus muricatus*, besides, crinoid stems, *Chonetes mesoloba*, *Athyris subtilita*, *Discina Missouriensis*, *Allorisma*, *Aviculopecten rectilateraria*. The middle layer is 4 inches thick, and is characterized by the great prevalence of *Martinia planoconvexa*; it also contains *Athyris subtilita*, *Rhynchonella* ———, *Hemipronites crassus*, *Chonetes mesoloba*. The upper layer is a rather compact gray limestone, the shelly surfaces of which are covered with one or two species of minute *Gasteropoda*, and comminuted fossil remains, amongst which the following forms have been recognized: Crinoid stems, *Chonetes mesoloba*, *Productus muricatus*, *Nucula* (?), *Myalina*, *Aviculopecten* (sp. ?) *Cythere*, &c. Fragments of the bony skeleton of Ganoid fishes are also found in this layer, but too imperfect for identification.

No. 5. Variegated yellow, blue, and chocolate-colored shales, 5½ feet.

No. 4. Tough, concretionary, bluish, earthy limestone, 5 to 8 inches. Crinoid stems, *Rhynchonella Uta*, *Martinia planoconvexa*, rare, *Productus muricatus*, *Chonetes mesoloba*.

No. 3. Bituminous shales, with *Petrodus*, 15 inches.

No. 2. Panora coal, 6 to 10 inches.

No. 1. Light blue shales, with obscure vegetable remains, exposed 1 foot.

The principal exposure is found in a low bluff, which rises immediately from the water's edge just within the western border of the county. The Panora coal here outcrops just above the water level. The strata dip quite rapidly to the westward, which carries all the lower beds beneath the river one or two hundred yards above the lower end of the exposure. In a ravine half a mile east of the above outcrop, the same strata are found at an elevation of about forty-five feet above the position they occupy in the river bluff. At both exposures the Panora coal has been exposed by Mr. Marshall, but it does not attain a greater thickness than ten inches, although the quality is very good.

In the northeast quarter of section 13, township 78, range 30, a thin seam of coal, three to six inches in thickness, was discovered by Mr. Marshall, in the valley-side a short distance above the last described exposures, which, I believe, is the representative of the Marshall coal. The coal outcrops at an elevation of about thirty-five feet above the river, or nearly on the same level as the Panora coal little more than half a mile to the eastward. The westerly inclination of the strata

is sufficient to admit a considerable thickness of beds between the upper layers in the river bluff exposures and this upper coal-bed. Indeed, midway between these exposures, arenaceous shales appear in a ravine, which recall, essentially, the appearance of the beds holding a corresponding position in the exposures, on the middle Raccoon above the mouth of Mosquito creek, where a maximum development of the middle division is attained, which nearly equals the average thickness of the whole middle coal formation. But at this locality, the middle division probably does not reach half the thickness it presents at that locality.

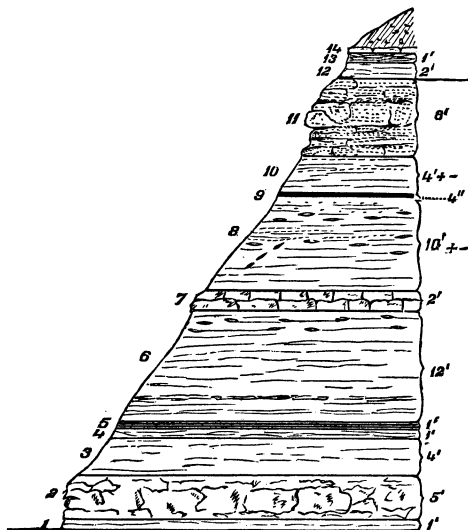
On Mosquito creek, seven or eight miles above its mouth, the Panora coal outcrops on Mr. Howell's farm, in the southeast quarter of section 31, township 80, range 29, where it has been worked by stripping off the superincumbent shales and drift materials. The coal is about twelve inches thick, and of very good quality. The overlying bituminous shale and bands of earthy limestone are richly stored with the fossils usually found associated in this horizon. The elevation of the coal at this locality, above the Middle Raccoon, corresponds very nearly to the level it occupies at Parker's mine, near the mouth of Mosquito creek, and also in the valley-side on the south side of the South Raccoon, two miles south of Redfield, which apparently indicates that the exposure at this locality lies upon the western flank, and but little below the crest of a low, anticlinal undulation which has a nearly north-south trend. Therefore, we might reasonably expect to reach the productive or lower measures within, perhaps, less than a hundred feet beneath the surface in the region east of Howell's, between the Mosquito and Panther creeks.

The first rock exposures observed as we ascend the valley of the North Raccoon are met with in the vicinity of Adel. On Miller's branch, in section 34, township 78, range 26, a vertical thickness of forty feet of strata is exposed, belonging to the upper part of the middle division, including a thin seam of coal near the top, which is but the representation of

the Marshall coal. Twenty feet below the coal a band of black carbonaceous shale occurs, which, though well-developed here, is not a persistent member of the formation. About a mile and a half northward, on Hickory branch, the same beds are again met with, presenting but slight differences from their appearance on Miller's branch, but showing the entire thickness of the upper sandstone of the middle division, and the lower carbonaceous horizon of the upper division. The Marshall coal is here one to four inches thick, and the accompanying shales are somewhat thicker than the corresponding beds at the former locality. The following section gives a general view of the character of the exposures on Miller's and Hickory branches:

FIG. 53.

Section near Adel on Hickory and Miller's branches.



No. 14. Dark buff, fragmentary, earthy limestone, 6 inches, imperfectly exposed high in the sides of Hickory branch.

No. 13. Black, carbonaceous shales, about 1 foot.

No. 12. Blue, slightly arenaceous shales, about 2 feet.

No. 11. Grayish and red sandstone, with arenaceous, shaly partings, 8 feet.

Furnishes a good building stone, and is much employed for lintels and sills. Imperfectly preserved *Sigillaria* were found here.

No. 10. Light yellow and blue clays, upper part slightly arenaceous, 2 to 4½ feet. On Hickory branch, about twenty inches from the base of the bed a thin layer of brown clay occurs, in which are found imperfect vegetable remains—grasses, ferns, etc., a minute Gasteropod, and a species of *Beyrichia*, closely resembling *B. fetoidia*.

No. 9. Marshall coal, 1 to 4 inches.

No. 8. Bluish, yellow, and chocolate-colored shales, with irregular ferruginous, nodular bands, and slightly arenaceous above, with obscure remains of plants, 10 to 12 feet.

No. 7. Light buff, soft, earthy limestone, 2 feet. Crinoidal remains: *Rhynchonella Uta*, *Hemipronites crassus*, *Chonetes mesoloba*, *C. mucronatus*, (?), *Productus muricatus*, *P. æquicostatus*, *P. longispinus*, rare; *Athyris subtilita*, *Spirifer cameratus*, *Spiriferina*, *Kentuckensis*, *Martinia planoconvexa*, *Phillipsia*.

No. 6. Alternating layers of gray, purple, and blue clays, with indurated bands and nodules above, about 12 feet.

No. 5. Black fissile, carbonaceous shales, 1 foot. Contains *Petrodus* and spines; Garoid remains probably referable to the genus *Palæoniscus*, *Aviculopecten rectilateraria*.

No. 4. Gray, calcareous shales, with numerous fossils, 1 foot. *Productus muricatus*, *P. æquicostatus*, *Chonetes mesoloba*, *Hemipronites crassus*, *Martinia planoconvexa*, *Athyris subtilita*, crinoid stems.

No. 3. Blue shales, 4 feet.

No. 2. Rather compact, irregularly bedded, earthy limestone, shaly above, 4 to 5 feet.

No. 1. Blue clays, exposed 1 foot, and ten feet above the North Raccoon at both localities.

Half a mile north of Adel, in the bed of Butler's branch, a thin bed of coal has been opened, which is overlaid by two feet of black carbonaceous shales and about the same thickness of arenaceous clays, upon which rests thirty-five feet of laminated arenaceous shales and a soft heavy bed and shaly iron stained sandstone with obscure vegetable remains. The black shales immediately overlying the coal present an interesting fauna, comprising the following species: *Discina Missouriensis*, *Productus muricatus*, *Chonetes mesoloba*, *Aviculopecten*, sp. *undet.*, and two or three other species of *Lamellibranchiata*, *Pleurotomaria*, *Bellerophon carbonaria*, and other minute species of *Gasteropoda*, *Orthoceras*, and small rhombic scales of *Palæoniscus* (?). The evidence

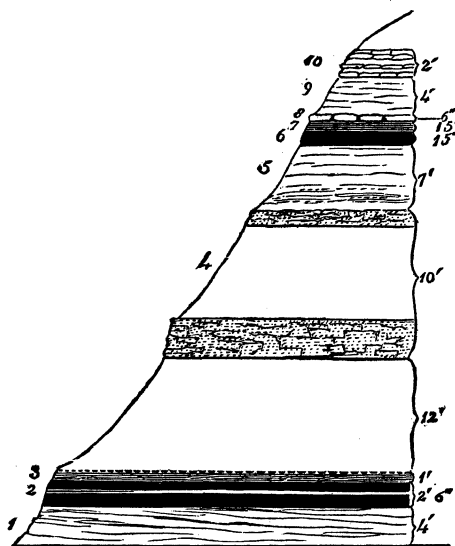
furnished by the fossils enumerated from the shales overlying the coal, seems to warrant the identification of this bed with the Lacona coal horizon, since we know of no other carbonaceous bed which shows the same assemblage of fossil forms. But this exposure occupies the same level as the beds of the middle division on Miller's branch, two miles to the south-eastward, which would seem to indicate a considerable northwesterly uprising of the beds in order to bring this coal, which belongs to the middle portion of the lower division, to the surface at this locality. Three miles to the northward the same beds are again met with in the vicinity of Chaney's, where they appear at an elevation but little above their position on Butler's branch. The Panora coal is not seen at this locality, and the arenaceous deposit intervening between these coals has an unusual development—if, indeed, the bed which composes the bulk of this exposure is the representative of that horizon.

About four miles northwestward from Adel, in a ravine on lands belonging to Mr. Chaney, in the southeast quarter of section 12, township 79, range 28, a thin bed of coal crops out at an elevation of about forty feet above the North Raccoon, where it has been wrought for several years. The coal is twelve to fifteen inches thick, and with the overlying beds affords a characteristic section of the Panora coal and the upper beds of the lower-division. About seven feet beneath the coal, a ledge of rather hard, gray sandstone was encountered in making some excavations at Chaney's mine. Half a mile southeast of Chaney's, in the southwest quarter of section 7, township 79, range 27, a two to three foot coal-bed outcrops fourteen feet above the level of the river, which is doubtless the equivalent of the Lacona coal. In the opposite side of the ravine a ledge of gray, shaly sandstone is seen which probably belongs to the same bed as that found underlying the coal at Chaney's mine. This exposure is known as Pittman's coal bank; the bed has not been regularly opened, and little could be ascertained respecting the quality of the coal. The following section shows

the character of the beds associated with the Panora coal at Chaney's mine, and also the apparent relation of this coal to the bed at Pittman's bank:

FIG. 54.

Section at Chaney's and Pittman's Coal Mines.



No. 10. Thin, irregularly bedded, earthy limestone, with shaly partings, 2 to 3 feet. This bed is imperfectly exposed, and contains the following fossils: *Productus muricatus*, common in the lower layer; *Martinia planoconvexa*, prevalent in the middle layer; *Hemipronites crassus*, *Athyris subtilita*.

No. 9. Blue clay, 4 feet.

No. 8. Blue, fragmentary, impure limestone, weathers brown, and more or less nodular, 6 inches. Contains numerous though poorly preserved fossils, comprising two or three species of *Bellerophon*, *B. carbonaria*, two species of *Pleurotomaria*, and other Gasteropods, *Nautilus*, several species of *Lamellibranchiata*, *Martinia planoconvexa*, *Athyris subtilita*, *Productus muricatus*, *P. longispinus*, (?), *Chonetes mesoloba*, *Discina Missouriensis*.

No. 7. Black, fissile, carbonaceous shales, 15 inches. *Petrodus* and spines, and other undetermined fish remains and coprolites, *Aviculopecten rectilateraria*, *Productus muricatus*.

No. 6. Panora coal, 12 to 15 inches.

No. 5. Dark blue clay, becoming arenaceous below, 5 to 7 feet.

No. 4. Light gray, rather hard, shaly sandstone, probably 5 to 10 feet. Opposite Pittman's coal bank this bed shows an exposed thickness of 4 feet, and

is nearly on the same level with the sandstone seen at the base of the section at Chaney's mine, where the above described beds occur. At Pittman's the following strata appear :

No. 3. Black, pyritiferous clays, resting immediately upon the coal, exposed 1 foot. Between this and No. 4 the slope is covered with debris; it is probably occupied by shales.

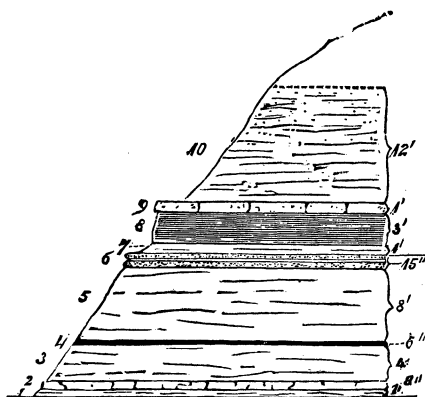
No. 2. Lacona coal, with a five inch clay parting, 2 to 3 feet.

No. 1. Ash-colored and dark blue clays, exposed 4 feet.

The strata at this locality have a slight westerly inclination. The above section is almost an exact counterpart of exposures on Coal creek, near Sandyville, Warren county, only here the Lacona coal is considerably thicker than it is at that locality.

On the head waters of Sugar creek, six miles southeasterly

FIG. 55.



of Adel, in the southwest quarter of section 5, township 78, range 26, near Mr. Samuel Huston's, and in lots 9 and 10 of section 6, on the estate of Mr. Frank Graham, exposures of the upper and lower beds of the middle and Upper divisions of the formation afford the following interesting section:

Section on Sugar Creek.

No. 0. Variegated shales, becoming arenaceous above, exposed 12 feet. Seen above Graham's quarry.

No. 9. Compact, blue, impure limestone, 1 foot. Contains—*Spirifer camera-tus*, *Martinia lineatus*, *M. planoconvexus*, *Athyris subtilita*, *Productus longispinus*, *P. Punctatus*, (?), *Chonetes mesoloba*, *Hemipronites crassus*, *Aviculopecten rectilateraria*, *Pernopecten* (Sp. ?), *Allorisma* and other undetermined *Lamellibranchiatus*, *Phillipsia*.

No. 8. Black, fissile, carbonaceous shales, 3 feet. Very regular, and contains the following fossils: *Petrodus* and spines, coprolites, *Aviculopecten*, *Discina*, and beautiful forms of delicate Polyzoa, and fucoid-like markings.

No. 7. Blue shales, 1 foot.

No. 6. Gray, compact and shaly sandstone, in two layers, separated by a clay parting, 15 inches. Imperfect remains of plants and charcoal particles are disseminated through the rock.

No. 5. Blue shales, 8 feet.

No. 4. Marshall coal, 6 inches. Seen near Huston's.

No. 3. Light blue shales, 4 feet.

No. 2. Yellow, impure limestone, 8 inches. Seen in bed of creek at Huston's. *Productus equicostatus*, *P. semireticulatus*, *Chonetes mesoloba*, *Hemipronites crassus*, *Athyris subtilita*.

No. 1. Blue shales, exposed 1 foot. The base of the section is 15 to 20 feet above the Raccoon river at the mouth of Sugar creek.

The attenuated condition of the sandstone, No. 6, is an interesting feature in the above section; the regular thickness of this bed is about eight feet, and it is here represented by a thin layer little more than one foot thick. A short distance below Huston's quarry, in the low bluffs on the opposite side of the stream, at an elevation of about twenty feet above the Marshall coal, an outcropping of sandstone, about eight feet in thickness occurs, the exact relation of which to the exposures given in the above section remains somewhat in doubt. It may, however, represent an excessive accumulation of arenaceous material in the lower part of the upper division, but it is the only instance of the kind as yet known in that horizon; or, it may represent a sudden thickening of the sandstone, between the Marshall coal and the carbonaceous shales; though its contrast to bed No. 6, and its apparent position is so much higher, that it would require a considerable westerly dip of the strata in order to reconcile the facts to the latter inference. There are one or two layers in this bed which are sufficiently durable to be used in ordinary masonry, but the mass of the bed is too friable to be of any value for this purpose. The bed contains *Sigillaria*, which is of common occurrence in the sandstone separating the two upper divisions of this formation, and which seems to furnish additional evidence of the identity of this sandstone and the thin bed No. 6. The carbonaceous shales, No. 8, is exposed at intervals in the banks of the stream for the distance of half a mile above Huston's, and finally disappears beneath

the bed of the creek on Mr. Graham's land. The overlying band of limestone affords a fair building stone, for which purpose it is much sought in this vicinity.

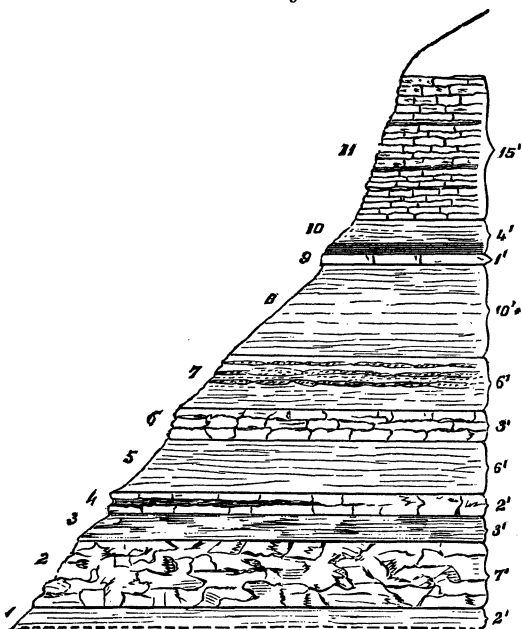
On one of the upper branches of Walnut creek, in the northeast quarter of section 16, township 79, range 26, the Marshall coal has been opened on lands of Mr. John Cutler. The coal is about ten inches thick, and said to be of excellent quality. It is overlaid by arenaceous clays, capped by a four-foot bed of soft, shaly sandstone, containing imperfect remains of ferns and *Calamites* and *Sigillaria*.

Upper Coal Formation. The area occupied by the Upper coal-measures in Dallas county is quite limited, the outcrops of the formation being confined to the divide between the Raccoon and North rivers in the southwestern townships.

Four or five miles southwestward of De Soto, on the line of the Chicago, Rock Island, and Pacific railroad, in the valley of Bulger creek, quite extensive exposures of limestones and

FIG. 56.

Section on Bulger Creek.



calcareous clays are met with, presenting a vertical thickness of about sixty feet of unequivocal Upper coal strata. The strata are seen in the cuttings along the railroad, where they have a very perceptible westerly dip along an exposure of half a mile or more. At the lowermost, or northeastern exposure, a slight anticlinal fold is observed which give the strata an easterly inclination from this point, though at a slight angle, which corresponds to the dip observed in connection with the Middle coal-measure strata on the Racoon below the mouth of Bulger creek. The preceding section was obtained at this locality, the base of which is estimated at seventy to eighty feet above the Middle coal-formation.

No. 11. Gray and light dove colored, more or less compact, even-bedded limestone, with marly partings, 15 feet. Contains *Fusulina cylindrica*, *Cyathaxonia*, crinoid and echinoid remains, Polyzoa, *Athyris subtilita*, *Spirifer cameratus*, *Spiriferina Kentuckensis*, *Martinia lineatus*, *Retzia punctillifera*, *Productus æquicostatus*, *P. semireticulatus*, *P. longispinus*, *Chonetes Verneuillanus* (?) *Hemipronites crassus*, *Meekelia striatocostata*, *Macrodon* (?) and Aviculoid shells, and undetermined fish remains, probably referable to the Ganoids.

No. 10. Black, fissile, carbonaceous shales, overlaid by dark, blue clays, which pass upwards into yellow clays, 4 feet. In the black shales *Petrodus* and spines occur. This layer is one foot thick.

No. 9. Compact, dark blue fossiliferous limestone, 6 inches to 1 foot.

No. 8. Variegated, reddish and buff shales, imperfectly exposed, 10 to 15 feet.

No. 7. Buff shales, 3 feet, passing upwards into arenaceous clays, with bands of indurated sandy shales, all 6 feet.

No. 6. Soft, gray, fossiliferous, earthy limestone, in three layers, 3 feet. In places is fragmentary and shaly.

No. 5. Gray shales, 6 feet.

No. 4. Soft, gray, shaly limestone, in places separated by layers of dark gray shales, and is sometimes found as a single, heavy, dark-colored layer, 2 feet, Contains *Myalina subquadrata*, and other common Coal-measure forms.

No. 3. Brick-red mottled clays, 3 feet.

No. 2. Very fragmentary, light gray limestone, with bands more argillaceous than others of a pale reddish tint, 7 feet. Contains abundant remains of fossils, among which are: *Fusulina cylindrica*, *Zaphrentis* (sp.?), crinoidal remains, *Orthis carbonaria*, O., sp. undet., *Athyris subtilita*, *Spirifer cameratus*, *Martinia lineatus*, *M. planoconvexus*, *Waldheimia*, (sp.?) *Cryptacanthia compacta*, *Productus æquicostatus*, *P. longispinus*, two species of *Lamellibranchiata*, and three species of *Gasteropoda*.

No. 1. Grayish, blue, calcareous shales, 2 feet, underlaid by reddish clays.

No. 2 of the above section is a persistent, well-marked and easily recognized horizon in the upper coal formation. Dr. White first recognized the bed at Winterset, in Madison county, and has pointed out the palæontological peculiarities from which it derives its greatest interest. There are a few fossil forms which, so far as present known, are peculiar to this stratum—*Cryptacanthia compacta*, *Tomoceras Gillianum*, are among the number ; but there are others which have a much greater vertical range, and some species, indeed, which begin their existence in the lower measures and range up through the middle formation into these upper coal horizons, and whose geographical distribution is co-extensive with that of the coal-measure series in the great basin of the Mississippi. The same bed has been traced along the border outcrop of the formation into Warren, and as far south as Appanoose county, on the southern border of the State. No. 11 furnishes a fair building stone, and also makes a very good quick-lime ; it is inclined to a shelly structure and irregular fracture, both of which qualities detract from its value for building purposes.

West of Bulger creek, on the tributaries of Bear creek, in the southwest corner of the county, Upper coal-measure limestones are met with at several localities. On Mr. Price's farm, in section 32, township 78, range 28, we find an obscure repetition of strata, the same as in the section last described. The bed No. 2 of that section, or the *Cryptacanthia* horizon, is imperfectly exposed, low in a ravine near Price's, and thirty feet above it, is found a flat layer of limestone about one foot thick, upon which rests a carbonaceous layer of the same thickness, which is doubtless equivalent to No.'s 9 and 10 of the preceding section. Overlying the black, carbonaceous band, light-colored, marly clays and several feet thickness of limestones, undistinguishable from those previously described on the Bulger, complete the section and furnish further proof of the equivalency of the strata at these localities. The last mentioned outcrop is seen near Mr. Price's house. A spring of cool, pure water issues from the

clays and is gathered in a reservoir formed in the single limestone layer underneath the carbonaceous band.

A quarter of a mile southeastward of Price's, in the southeast quarter of section 32, township 78, range 28, on lands of Mr. James Brown, the same beds outcrop a little below the level they occupy at Price's. At Mr. Barnett Wilson's, in section 36, township 78, range 29, the carbonaceous layer and the overlying limestone bed are again met with in a ravine but a few feet below the general level of the uplands. The upper limestone furnishes an abundant supply of very good building stone, superior to that quarried in the same bed on the Bulger.

Economical Geology—Coal. It will be apparent, after having become familiar with the coals in this county, that by far the greater number of exposures of this valuable mineral product belong to the thin deposits of the Middle coal formation. Although these deposits furnish a very excellent combustible material, there being comparatively little *pyrite* or other impurities associated with these coals, owing to their thinness, they can be hardly worked as successfully as the heavier beds in the Lower coal-measures. However, at the present time, these beds are being wrought at many localities, and the local demand for coal is largely supplied from them. At Redfield, on the South Raccoon, and in the northern tier of townships, the upper bed of the lower coal formation is brought to the surface, and affords a fair quality of coal, two to three feet in thickness. It is not improbable that in the northern portion of the county, still lower beds in the productive measures will be discovered, at no great depth from the surface. As soon as the demand for mineral fuel shall warrant the necessary outlay, these lower coals doubtless will be sought by shafting, at almost any point north of the Raccoon and South Raccoon rivers, with the certainty of reaching the horizons of the heavy coal deposits, at depths varying from a few feet to one hundred and fifty feet beneath the surface in the valleys.

Building Materials. The limestone of the Upper coal-

formation in the south-west portion of the county will eventually furnish the main supply of stone for building purposes. Some of the sandstones in the Middle coal-measures, also the thin bands of impure limestone, afford a tolerable substitute, in the absence of a better material. The sandstone between the two upper divisions of this formation sometimes affords a very fair freestone, On Hickory Branch, near Adel, this bed is extensively quarried and largely used in building in the town and vicinity.

Quick-lime must also be almost wholly derived from the limestones of the Upper coal-formation when the supply from erratic sources is exhausted. In the vicinity of Mr. Huston's, on Sugar creek, in Boone township, the Drift has afforded a large supply of limestone boulders for the manufacture of lime. These boulders are sometimes of many tons weight, and the labor of transferring them to the kilns often involves as great, or even greater, outlay of time and expense as in quarrying. The lime derived from this source is said to be stronger and is more valued than that obtained from the limestones of the Upper coal-measures.

The materials employed in the manufacture of common brick are abundantly supplied by the superficial deposits. Clay for potter's use, and fire-brick, may be also found in the under clays of the coal-beds in various parts of the county.

With the facilities afforded by two main lines of railway, the Chicago, Rock Island, and Pacific, which traverses the southern portion of the county, and the Des Moines Valley railroad which passes northward through the eastern townships, the natural productiveness of the soil, and the beauty of the country which can be almost indefinitely enhanced by moderate expenditures of time and taste, Dallas county must soon become one of the most important counties in the valley of the Des Moines.

8. WARREN COUNTY.

Warren county lies immediately south of Polk county, and

is bounded on the east by Marion, on the south by Lucas and Clarke, and west by Madison county. In shape, the county is square, consisting of sixteen townships, having an area of 576 square miles.

General Surface Features—Drainage. The Des Moines river forms the north boundary of the northeast township, where it receives all three of the three rivers, or the North, Middle and South rivers, within a distance of eight miles. Although the mouths of these streams are so near together, their courses diverge in a westerly and southwesterly direction, draining one of the finest regions in the State, embracing an area of about fifteen hundred square miles. With the exception of the southeast township which is watered by Whitebreast creek, the entire surface of the county is drained by the "Three rivers" and their affluents.

Surface Configuration. The valleys of the Three rivers are similar to one another, embracing narrow tracts of bottom-land, and bordered by more or less gentle acclivities from seventy-five to two hundred feet in height. The valley-sides are almost always steepest upon the right or south margin, the north side usually ascending more gradually to the uplands. The uplands between the streams are generally gently undulating in the eastern portion of the county; but in the western half, in the region of the Middle coal-measures, the divides ascend more abruptly from the valleys, and in some sections the surface is quite rolling, though not broken. Those portions of the divides between North river and the Raccoon and between North and Middle rivers, within this county, are beautiful tracts of undulating prairie, interspersed with frequent groves, and intersected by numerous small streams and shallow ravines which perform a thorough drainage of the region. In the southwestern portion of the county the uplands are rolling, though the only section that approaches a broken character is a limited area on Wolf creek, a branch of the Whitebreast.

Forest. The forest growths at present are mainly along the larger watercourses, where considerable bodies of timber

are found consisting of the varieties of trees common in central Iowa. Approaching the Des Moines the timber increases in quantity, and in many places it has encroached upon the uplands to so considerable an extent, as to give to those portions of the county the character of a heavily wooded district. Ascending the streams, the forests become more and more circumscribed, and are finally, on the smaller streams, wholly confined to the valleys. In the southwestern portion of the county, the uplands present uninterrupted prairie surfaces which stretch away to the southwestward, merging into the great prairie of the watershed divide in Clarke county. In all sections, however, the timber is rapidly encroaching upon the prairies, and at the rapid rate of increase observed during the last decade, it will not be many years before even the more sparsely wooded portions of the county will abound with tracts of thrifty young forests.

Soil. The soil over the entire surface of the county is unexceptionably fertile, consisting almost uniformly of a fine, black loam. However, in the northeastern townships, some portions of the uplands have been denuded of the original drift soil exposing at the surface over more or less limited tracts, the shales of the Lower coal-measures from which are derived the light-colored, clayey, and sandy soils which are so frequently met with in the near vicinity of the Des Moines river.

Water. Excellent water is obtained by means of wells at moderate depths in all portions of the county. The larger streams furnish valuable water-power, and the smaller ones afford inexhaustible supplies of water for stock, the raising of which is already become an important feature in agricultural pursuits in the county. Springs are common in some portions, particularly in southeastern townships, where they not unfrequently appear high in the hill-sides.

Geology. Warren county presents an interesting field for geological research, and owing to its position in the region of the coal-measures, the explorations in this section have had

an important practical bearing upon the development of the economic resources of this group of strata. The geological formations that appear at the surface in this region consist of the Lower, Middle, and Upper coal-formations, and the Post-tertiary deposits.

Post-tertiary—Drift. The Drift deposits, consisting of mottled bluish and yellow clays, sand, and gravel, are generally distributed over the county, though they do not attain as great a thickness here as in the counties to the northward. The thinning of these deposits is due to the extensive erosion to which they were subjected during the time when the valleys were in process of reëxcavation, for that the valleys, at least many of them, date their origin prior to the Post-tertiary period, there can be little doubt. It mantles all the divides in the central and western portions of the county, and also occurs largely in the valleys which it once entirely occupied. But upon the valley-sides the deposit is very thin, and often entirely removed, exposing the rocky strata, or covered only by a thin layer of soil and debris. In the uplands in the vicinity of the Des Moines, these deposits are frequently wanting; but these denuded areas are comparatively of small extent.

The modified portion of the Drift is not as well marked in this region as it is in others, and the terrace formations are inconspicuous features in the conformation of the valleys. In this respect the valleys may be said to possess characteristics in greater or less degree peculiar to them, and which are applicable also to nearly all the streams that flow into the Des Moines river, upon its right bank between the confluence of the Raccoon river and the intersection of the Missouri State line. The present flood-plains are invariably composed of fine alluvial deposits, which occupy nearly the entire width of the valleys. It is very seldom we see in this region those high, well-marked gravelly terraces or "second-bottoms" which occur along the streams in northern Iowa. The absence of these interesting formations is probably due to the streams having eroded their beds deeply into the rocky strata, which

has resulted in the denudation or removal of the surface deposits, from which the terraces derived their materials, to a much greater extent than would take place in a region where the streams rest in great part or wholly in the Drift.

Boulders are not commonly met with upon the uplands, but in the ravines they have accumulated in considerable quantities. Masses of partially abraded red-quartzite occur in these deposits with usual granitic and gneiss boulders prevalent in the Drift. Upon some of the uplands a fine, light colored clay deposit containing scarcely any coarse materials is not unfrequently met with, the origin of which is difficult to determine. It resembles the Bluff Deposit of western Iowa in the firmness of its composition, and it differs from the clayey drift immediately derived from the subjacent coal-measure shales in as much that it forms a mellower soil and more porous subsoil.

Coal-Measures. All three formations of the coal-measures are found in Warren county. The lower measures outcrop over perhaps one-third the area of the county, and are confined to the northeastern townships. The middle formation occupies the larger remaining portion of the county, or comprising about eight townships. The Upper coal-measures cut across the southwestern township, and appears in isolated patches in the uplands at several localities in the interior of the county.

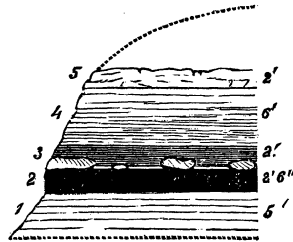
Lower Coal Formation. It is doubtless only the upper portion of the productive or Lower coal-measure that appears at the surface; and hence it is we find but one or two coal horizons of any considerable thickness in this formation, exposed to view in the county. The lower beds in the formation can be reached by boring, or by ordinary shafting, though it is exceedingly difficult to direct such practical explorations with the surety of success, when we take into consideration the variability in the thickness of the coals throughout this member of the coal-measures. And also the identity of many of the exposures is not well established, for the reason that our knowledge of this formation at the

present time is more of a general than detailed character. The formation, as it appears in this county, is made up of argillaceous and arenaceous shales, with beds of soft sandstone and coal. Irregular bands of *septaria*, and occasional layers of brownish, impure limestone occur in various strata of the shales at different localities.

On the North river in Greenfield township, there are a few out-croppings exhibiting at least two beds of coal, including also a third thin carbonaceous layer. In the vicinity of Hoover's mill, (section 22, township 77, range 24), a two to three foot coal-bed is said to appear in the bed of the river at low water, it is overlaid by bluish and chocolate-colored shales which enclose a six inch layer of coal at an elevation of about twenty feet above the lower bed. A thin layer of rather compact thin bedded sandstone is associated with these strata which has afforded a limited supply of building material. In the shales ferruginous nodules occur, but not in abundance. Above the upper coal-seam fragments of brownish earthy limestone are found which contain *Zaphrentis* and *Athyris subtilita*. However, the exposures were too imperfect to render a detailed study of the locality practicable.

Two miles above Hoover's mill, in the southwest quarter of section 29, township 77, range 24, a two or three foot bed of coal has been opened on Mr. George Dillard's farm, where the following section was made:

FIG. 57.



Section at Dillard's Coal-mine.

- No. 5. Gray silicious limerock, 1 to 2 feet.
- No. 4. Blue and yellow shales, 5 to 6 feet.
- No. 3. Black carbonaceous shales, sometimes replaced by nodular, fossiliferous earthy limestone, 1 to 2 feet.
- No. 2. Coal, $2\frac{1}{2}$ to 3 feet.
- No. 1. Light blue shales, about 5 feet.

A slight northwesterly inclination of the strata carries the coal beneath the bed of the river a few hundred yards distant. The coal is a very good quality and has a large local demand for blacksmithing purposes. The outcrop at this locality facilitates the easy working of the bed, which was being creditably conducted by Mr. Manuel, the lessee. This bed is probably the same as that which has been mined at Bussey's on the North Raccoon, in the southeast corner of Greene county. This identification seems to be warranted by the lithological characters of the associated strata, and especially by the presence of the nodular limestone band, No. 3, whose fossils, as given in the accompanying list, are quite numerous and of the same species as those found in a similar stratum at the above mentioned locality: *Zaphrentis*, *Spirifer opimus* (?), *Athyris subtilita*, *Productus muricatus*, *P. semireticulatus*, *Rhynchonella Uta*, *Nucula ventricosa*, ———, *Pleurotamaria* ———, *Loxonema* (sp. ?) *Bellerophon* (sp. ?), and detached scales of *Palæoniscus* (?).

At Lockridge's mill, in the southeast quarter of section 30, township 77, range 24, a thin seam of rotten coal, accompanied by variegated shales, crops out in the right bank of the river, between twenty-five and thirty feet above the water level. A thin layer of grey calcareous rock occurs in the base of the exposure, and in the slope above the coal, fragments of brown, earthy limestone are seen, but not in place. This exposure is probably equivalent to the beds which are seen in the same bank of the river, half a mile below Hoover's mill. A quarter of a mile southeast of the mill, also in section 30, Mr. James Lockridge has opened a quarry in a four foot bed of grayish sandstone, which probably overlies the strata that outcrop near the mill. The rock is heavy bedded, with shaly micaceous layers, and though it is quite soft, it is much used in the neighborhood for ordinary underpinnings. Large concretionary masses in the bed afford a more durable building stone.

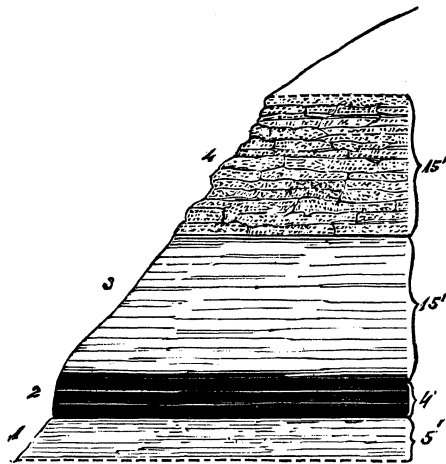
Above Lockridge's no more exposures of Lower coal-measure strata were seen, the formation passing beneath the

Middle coal-measures before reaching the mouth of Badger creek. Lower down the valley, however, a short distance above the crossing of the Indianola and Des Moines road, a three or four foot bed of coal is reported to have been found at a depth but a few feet below the level of the bottoms. The excavation had been abandoned, and was filled with rubbish at the time the locality was visited, and nothing definite could be ascertained regarding the character of the exposure.

Some two or three miles to the northeastward of Hartford, in the base of the bluffs bordering the right side of the Des Moines valley, several openings have been made in a four-foot coal-bed, on lands belonging to Mr. Taylor. The coal is probably ten to fifteen feet above the level of the river, and with the associated strata as well as the physical aspect of the bed itself, as exhibited in the annexed section, it has an unmistakable resemblance to the Des Moines coal horizon:

FIG. 58.

Section at Taylor's Coal-mine.



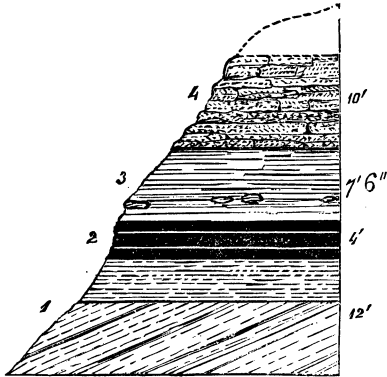
- No. 4. Shaly sandstone, with *Sigillaria*, exposed 15 feet.
- No. 3. Blue shales, 15 feet.
- No. 2. Coal, 2 to 4 feet.
- No. 1. Bluish clays, 5 feet exposed.

The coal is quite variable in thickness, and is divided in two or three layers by thin seams of clay—the lowermost layer is regarded the best in quality, being freest from *pyrite*. Notwithstanding the distance from any manufacturing town,

the mines at this locality are quite extensively wrought.

The first exposure found on Middle river is that at Allen's mill, three miles northwest of Hartford, where an interesting section of Lower coal strata appear in the low bluffs upon the left side of the stream, which presents the appearance given in Fig. 59.

FIG. 59.



Section at Allen's Mill, Middle river.

- No. 4. Yellow sandstone, shaly below, 10 feet exposed.
- No. 3. Yellow and dark blue shales, with nodular limestone band, 7½ feet.
- No. 2. Coal, 3 to 4 feet.
- No. 1. Arenaceous shales, obliquely laminated below, exposed to water level 12 feet.

The coal in the above exposure is probably the same as that seen at Taylor's mine. Like the coal at that locality, it is separated by two thin seams of shale, and presents the usual thickness of that bed. An interesting example of the irregular deposition of material during the formation of these deposits may be seen at the upper end of the exposure where the shales No. 3 are replaced by the sandstone No. 4, which rests immediately upon the coal. There is no indication of any displacement of strata, such as might be produced by a land-slide, and the thickening of the sandstone, which at this point is thirty feet, still further renders that supposition improbable. The strata have a slight westerly inclination. The outcrop of the coal is very advantageous for mining operations, but as yet it has been

worked only to a limited extent, there being little demand for its product.

At Watt's mill, two miles above the last mentioned locality, a heavy deposit of coal is said to occur in the river bed five to ten feet below ordinary stage of water, masses of the coal having been from time to time detached and washed up on the shore by the freshets. In the adjacent river bank, blue shales, containing concretionary masses, overlaid by a thickness of twenty-five feet of soft sandstone and micaceous shales, present a vertical exposure of forty-five feet above the level of the river. The general similarity of the exposure seen at this locality, and that at Allen's mill, would seem to be sufficient proof of their identity.

Just below the mills at Summerset, in the right bank of Middle river, two thin seams of coal outcrop in connection with layers of shales, sandstone, and limestone, affording the following section:

Section at Summerset, Middle river.

No. 12. Thin band of dark gray, nodular limestone, containing the following fossils: *Rhynchonella*, *Uta*, *Athyris subtilita*, *Spirifer cameratus*, *Hemipronites crassus*, *Chonetes mesoloba*, *Productus muricatus*, *P. æquicostatus*, *Pernopecten*, and one or two other undetermined *Lamellibranchiates*, *Bellerophon*, *Pleurotomaria*, *Loxonema*.

No. 11. Yellow and red indurated shales, 5 feet.

No. 10. Dark brown, ferruginous limestone, 6 inches.

No. 9. Light blue shales, 4 to 5 feet.

No. 8. Bluish gray, earthy limestone, 6 to 8 inches. Fossils: *Fusulina cylindrica*, *Zaphrentis*, crinoid remains, Polyzoa, *Orthis carbonaria*, *Spirifer cameratus*, (?), *Spiriferina Kentuckensis*, *Martinia planoconvexa*, *Athyris subtilita*, *Retzia punctilifera*, *Hemipronites crassus*, (?), *Chonetes mesoloba*, *Productus æquicostatus*, *P. muricatus*, and fragments of undetermined fish-spines.

No. 7. Blue, gray, and yellow gritty shales, with *selenite* crystals, 8 feet.

No. 6. Coal, 6 to 14 inches. At the upper end of the exposure, this bed is divided by a four-inch clay parting, each layer being little more than 6 inches thick.

No. 5. Mottled gray, blue, and yellow shales, 5 feet.

No. 4. Grayish, concretionary sandstone, shaly above, 4 feet.

No. 3. Red indurated shales, with ferruginous nodules, and light blue indurated shales, arenaceous above, with *septaria*, 10 feet.

No. 2. Blue and yellow, mottled shales, capped by a thin layer of sandstone, with a two-inch seam of coal in the lower part, 4 feet.

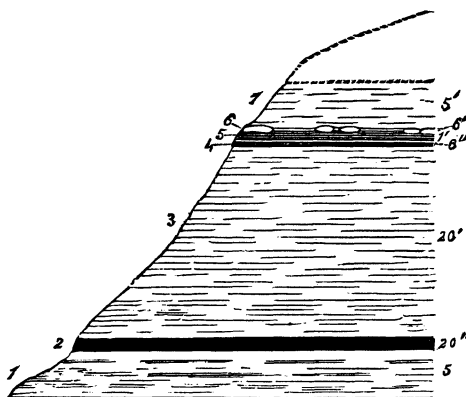
No. 1. Soft, shaly, micaceous sandstone, exposed to water level, 2 feet.

The equivalence of the strata represented in the foregoing section is not known. However, they probably occupy a lower position than the Des Moines coal horizon, and the thin deposits of coal may be referable to certain layers found in the valley of the North Raccoon in the extreme north of Dallas county.

Three miles north of Sandyville, in a ravine upon the right margin of South river, a four-foot coal bed is being mined on lands of Mrs. Parsons, and a similar bed is reported to have been opened on David Douglas' farm a mile or two to the eastward. The coal at the Parsons' mine is separated into two layers of nearly equal thickness by a thin seam of pyrite or pyritiferous shale. It is said to hold its thickness on the south side of the ravine, but in the opposite side it becomes alternated to unworkable thickness, and rises in the same direction. All the entries upon this side have been abandoned on account of the thinning out of the coal, but that in the south side, which runs parallel with the ravine a distance of above one hundred yards, continues to hold out and has produced a large quantity of very good coal. A few hundred yards eastward of the mines, just below the mouth of the ravine, in the bluffs on the river, the following

FIG. 60.

Section at the Parsons' Coal Mine, South river.



exposure occurs, presenting the same coal-bed which is here but a few inches thick, besides an underlying bed low in the river bank:

No. 7. Dark-blue and yellow shales, 5 feet exposed.

No. 6. Dark, very compact or brittle, impure limestone, in irregular nodular masses, sometimes entirely replacing the black shales No. 5. Contains numerous fossils, among which are the following species: *Productus muricatus*, *Rhynchonella Uta*, *Athyris subtilita*, *Aviculopecten*, (sp. und't.), *Pleurotomaria*, *Loxonema*, *Petrodus*, and spines.

No. 5. Gray shales, 6 inches. In the ravine-outcrop this bed is represented by an irregular layer of bituminous fissile shale, containing *Martinia planoconvexa*, *Athyris subtilita*, *Productus muricatus*, *Discina*, *Aviculopecten*.

No. 4. Coal, 4 inches. This is the representative of the four-foot bed that is being mined in the ravine a short distance east of the river bluff exposure.

No. 3. Blue shales, imperfectly exposed, 20 feet.

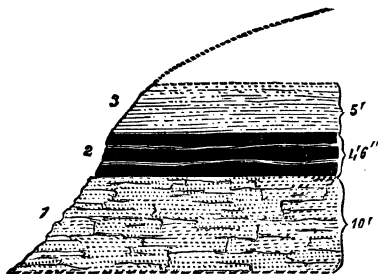
No. 2. Coal, very irregular in thickness and highly pyritiferous, 3 to 20 inches.

No. 1. Dark-blue shales, with thin bands of nodules, exposed to water level, 5 feet.

The coal of No. 4 and its immediate associated layers Nos. 5 and 6, bear a marked lithological and palæontological resemblance to the coal described at Dillard's mine on North river. The relative elevation of the upper coal above the river-level at its two outcrops shows a quite rapid inclination of the strata to the southward; this is also indicated by the dip of the lower coal-bed. The latter bed is too irregular, besides being excessively charged with *pyrite*, to be of any value.

Ascending the valley of South river from the last described locality, the Lower coal strata are not again seen until reaching a point between the mouths of Otter and Squaw creeks, where they apparently rise again, bringing to view a stratum of coal which is referred to the Des Moines coal, the uppermost coal-bed in the Lower measures. The first of these exposures is met within a ravine on the south side of South river, two and a half miles south of Indianola, at Helm's coal mine. The coal is here two feet thick, and is overlaid

FIG. 61.



and underlaid by soft sandstone and arenaceous shales. About three miles to the westward of Helm's mine, a four and a half foot bed of coal has been opened on Mr. Randolph's farm, where the following section was obtained:

Section at Randolph's Coal-mine, South river.

No. 3. Yellow, arenaceous shales, 5 feet exposed.

No. 2. Coal, $4\frac{1}{2}$ feet.

No. 1. Blue and yellow soft sandstone and arenaceous shales, exposed 10 feet.

The coal is separated into three layers by thin clay partings. The upper clay seam occurs eighteen inches from the top, and the lower one five inches from the bottom of the bed. The coal has a slight inclination in a southwesterly direction. Although the bed is hardly well opened, the quality is as good as the average of the coals in the Lower measures. The identity of the coal at this locality has not been settled beyond question; but the physical appearance of the bed approaches more nearly that of the Des Moines coal than any other coal horizon with which we are familiar. The bed is accessible for mining by the ordinary drift or entry process, and as soon as the projected north and south lines of railroads are completed through this region, this, as well as the other coals in the Lower coal-measures will afford an important revenue to the county.

The southwesterly dip of the strata doubtless carries these beds below the level of the South Raccoon river again in the western portion of the county, although the infrequency of rock exposures in that section has made it exceedingly difficult to procure data by means of which the limits of the productive or Lower coal-measures can be accurately defined in that direction.

In the extreme southeast portion of the county, on Mr. Gideon Jenck's land, northeast quarter of section 24, township 74, range 22, a coal-bed three and a half feet thick crops out on Winn's Branch, a tributary of the Whitebreast, where a limited exposure may be seen, of which the following is a section:

Section at Jenck's Coal-mine.

- No. 4. Soft, yellow, micaceous sandstone, exposed 3 feet.
- No. 3. Bituminous shales, 4 feet.
- No. 2. Coal, 3 feet 8 inches.
- No. 1. Light-colored shales, exposed 2 feet.

The coal at the above locality outcrops at several places along the branch in the distance of half a mile, but no regular mining was in operation at the time the locality was visited. The quality of the coal seems to be good, and the bed can be easily worked during the greater portion of the year. The position of this bed in the series has not been determined. Its proximity to exposures of well authenticated Middle coal-measure strata on the Whitebreast, a mile and a half to the westward, might seem to indicate its relation to some of the upper horizons in the Lower coal formation. At the same time, we cannot overlook the lithological resemblance of the associated strata—which are too limited, however, to throw much light on the equivalence of the bed—to the Lacona coal, an irregular development of bituminous material in the lower part of the Middle coal-measures, although the bed at this locality is nearly as thick again as the Lacona coal at any of its authentic exposures. A similar bed appears in a ravine about a mile south of Jencks' bank, in the northeast quarter of section 25, where it is said to be twenty to twenty-five inches thick.

Middle Coal Formation. The Middle coal-measures, as has been already stated, outcrops over as large an extent of surface as that occupied by both the Upper and Lower coal formation, or about equal to half the whole area of the

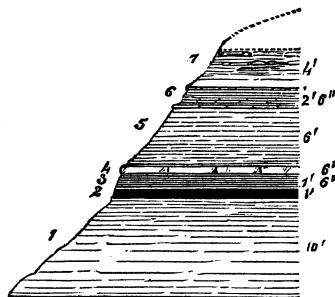
county. The eastern border of the formation forms an irregular line which may be approximately defined as follows: Commencing at the extreme southeast corner of the county the border outcrop passes northward along the eastern border of the county to a point on Coal creek, a mile or two east of Sandyville, embracing the whole of the fine upland tract to the east of Otter creek, in which Coal, Wolf, and Cotton creeks take their rise; thence the line retreats up the valley of South river to a point a few miles above the confluence of Squaw creek, when it suddenly trends north-eastward as far as Indianola, and perhaps even farther eastward in the divide between South and Middle rivers forming a bay-like area which is occupied by the Lower coal-measures; from Indianola a line passing in a northwesterly direction through Greenbush to a point on North river little below the confluence of Badger creek, from which locality the line pursues a northerly course to the northern boundary of the county. The western border of the formation is not as well defined as the eastern border limits, from the fact that in that direction this formation, as well as the succeeding Upper coal formation, is more deeply buried beneath the superficial deposits so that exposures in that quarter are of rare occurrence.

The first exposures of these strata met within the north-western part of the county, appear on Badger creek, a mile above its confluence with North river, where beds equivalent to the lower division of the formation afford a limited vertical section. The uppermost exposure is in the southwest quarter of section 19, township 77, range 25, on Mr. Josiah Smith's farm, showing the horizon of the Panora coal and the overlying limestones and shales, capped by an imperfectly exposed arenaceous bed, which separates the lower and middle divisions of the formation; the coal, however, is not exposed above the level of the stream. The limestone layers have been quarried to a limited extent, but it is not a safe material even for the most ordinary building purposes where it is exposed to the atmosphere and frosts. Descending the

creek in a southeasterly direction, the strata dip at a considerably more rapid rate than the fall in the stream in the same direction; and before reaching its mouth the upper beds of the exposure mentioned above are lost to view beneath the level of the creek. Below this point, however, the strata again rise, bringing to view the Lower coal-measures, four or five miles to the eastward, at Lockridge's mill. Above the mouth of Badger creek no exposures are met with in the valley of North river, within the county. But in the adjoining county of Madison, the Middle coal formation, is known to pass beneath the Upper coal-measures within a few miles of the western boundary of Warren county.

The same beds are again shown on a branch of Middle river, seven miles due east of the Badger creek exposures, and a mile and a half southwest of Greenbush, where a very satisfactory section was obtained as given below:

FIG. 62.



Section near Greenbush.

No. 7. Blue and yellow clays, with indurated bands, exposed 4 feet.

No. 6. Soft, bluish yellow, earthy limestone, in three layers, separated by shaly partings, 2 feet. The *Productus muricatus* is very abundant in the lower layer, while in the upper one *Martiniæ planoconvexa* prevails besides other forms usually found in this horizon.

No. 5. Dark blue shales, 6 feet.

No. 4. Rather hard, blue, impure limestone, forming an irregular nodular band, 6 inches. *Productus muricatus*, *Bellerophon*, etc.

No. 3. Black, carbonaceous shales, with *Petrodus*, 6 inches.

No. 2. Panora coal, 1 foot.

No. 1. Light and dark blue shales, exposed to bed of branch, 10 feet.

The coal at this locality has been wrought by stripping off the superimposed strata and earth. That portion of the section, No. 3 to 7 inclusive, is precisely like the exposures

on Badger creek. In the upland between Middle and North river, higher strata in the Middle coal-measures doubtless occur, but as yet we have learned of no exposures, save a few feet along the deeper watercourses which belong to the lower division of the formation.

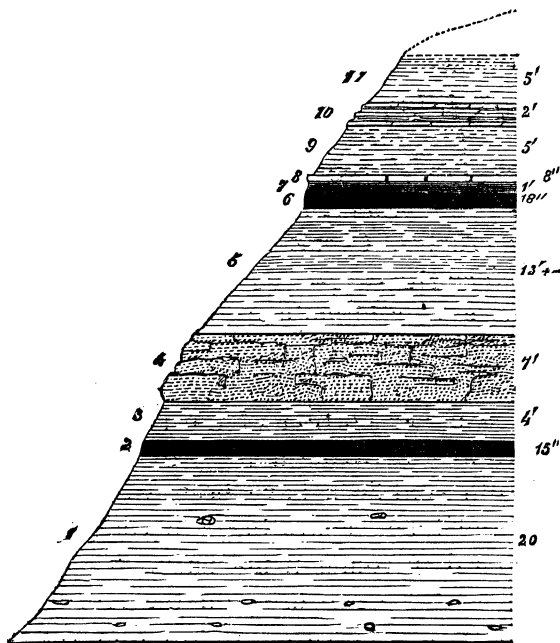
So far as known, no Middle coal strata outcrop immediately along South river. But in many of the small branches and ravines upon the south side of the valley, and also at a single locality on the north side at Ginder's, these strata have been found at several places. The first exposure observed on ascending the valley is formed on a small branch on the east side of the river, near the Indianola and Knoxville road, probably in the northeast quarter of section 30, township 76, range 22. At this locality a fifteen inch coal-bed outcrops in the bed of the branch, and is overlaid by the black shales and fossiliferous limestone layers which characterize the horizon of the Panora coal, to which this exposure doubtless belongs. This outcrop is probably thirty-five to forty feet above the level of South river. In the adjacent valley-slope a considerable thickness of argillaceous arenaceous shales appear in the road-side which probably belong to the base of the middle division of the formation.

Upon the north side of the valley in the northwest quarter of section 25, township 76, range 23, on Mr. Alex. Ginder's estate, the same beds are again met with at about the same elevation above the river as at the former locality. The Panora coal at this place is said to be from fifteen to twenty inches thick, and at one time was worked to a limited extent by stripping off the overlying materials. The limestone layers overlying the coal are replete with organic remains which present the same association of species and abundance of individuals which constitute so prominent a palæontological feature of this horizon. About one-quarter of a mile east of the coal bank, at an elevation of about one hundred feet above the river, a heavy bedded silicious limestone outcrops, which has been extensively quarried for underpinnings, &c.

On Coal creek, a mile and a half southeast of Sandyville, several interesting exposures were examined, exhibiting a vertical thickness of sixty feet, including the horizon of the Panora coal and an underlying twenty-inch coal-bed, the equivalent of the Lacona coal. These strata are finely exhibited in the low bluff, near the ford on Mr. Anthony's farm, (northwest quarter of section 26, township 76, range 22), at which place the following section was measured :

FIG. 63.

Section on Coal creek, near Sandyville.



- No. 11. Blue shales, arenaceous above, exposed, 5 feet.
- No. 10. Thin bedded, fossiliferous, impure limestone, 2 feet.
- No. 9. Grayish-blue, indurated shales, 4 to 5 feet.
- No. 8. Impure, brownish, fossiliferous limestone, 8 inches.
- No. 7. Carbonaceous and gray shales, with fossils, 15 to 20 inches.
- No. 6. Panora coal, 18 inches.
- No. 5. Light-colored shales, about 13 feet.
- No. 4. Bluish gray, rather compact micaceous sandstone, 5 to 8 feet.

No. 3. Blue shales, about 4 feet.

No. 2. Lacona coal, 15 to 20 inches.

No. 1. Light and blue clays, with ferruginous nodules and *septaria*, underlaid by gray, shaly sandstone, exposed to bed of creek, 20 feet.

Bed No. 10, of the above section, consists of three layers of bluish-gray, earthy limestone separated by clay partings. The lower layers contains *Productus muricatus* in great numbers; *Martinia planoconvexa* occurs abundantly in the middle layer, while in the upper band *Productus æquicostatus* is the prevailing fossil. Besides the above species, the following are found in these layers: *Chonetes mesoloba*, *Hemipronites crassus*, *Edmondia*, and crinoidal remains. The black carbonaceous shales, No. 7, afford a small species of *Lingula*, *Productus muricatus*, *Macrocheilus* (?) *Petrodus* and spines.

The cap-rock, No. 8, contains *Rhynchonella Uta*, *Athyris subtilita*, *Martinia planoconvexa*, *Spiriferina Kentuckensis*, *Hemipronites crassus*, *Chonetes mesoloba*, *Productus muricatus*, *Pleurotomaria* ——. The Lacona coal, No. 2, is sometimes overlaid by bituminous, slightly calcareous shales in which are found *Productus æquicostatus*, common, *P. muricatus*, *Leda bellastriata*, *Bellerophon carbonaria*, *Loxonema*, etc. The upper portion of the section, including the Panora, appears in a ravine a few yards south of the bluff exposure. Both coal-beds have been wrought on a small scale. The sandstone separating the coals is sufficiently durable to be used in common masonry. The entire section closely resembles the exposures on the North Raccoon at Chaney's, four or five miles above Adel, in Dallas county, with which it is identical. The strata have a slight westerly inclination, which in the distance of half a mile or less brings the Panora coal down to the level of the creek, as shown at the exposures in the northeast quarter of section 27.

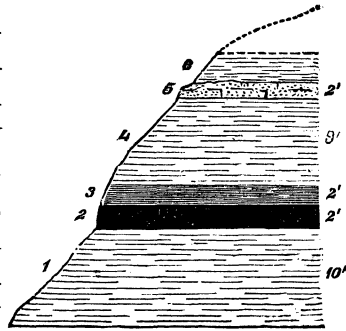
Below the above locality no rock exposures are seen along the course of Coal creek, within the county. But above, in the direction of Hammondsburg, exposures are more or less

frequent, and in the immediate vicinity of the latter place the middle and upper divisions of the formation are well developed.

In the uplands to the southward of coal creek, and east of Otter creek, in Belmont and Whitebreast townships, comparatively few rock exposures are met with. Those which have been examined, show the same beds as seen at Anthony's. Of these may be mentioned the coal-banks on sections 2, 4, 21, and 27, township 75, range 22, or Belmont township, the two former on branches of Coal creek, and the latter on tributaries of Wolf creek. All these exposures display but a limited vertical section. The coal very uniformly averages about fifteen inches in thickness, and is very good in quality. None of the banks are extensively worked; indeed, the coal, in most cases, is obtained by stripping off the overlying earth, no regular entries having been made into the bed.

In the south part of Whitebreast township, we find the same beds again, with a fine exhibition of the coal-bed beneath the Panora coal, which has been designated as the Lacona coal, from its fine development in the vicinity of the village bearing that name. At Dunkin's mine, on Flank creek, in the northeast quarter of section 4, township 74, range 22, this bed attains the thickness of thirty inches, and, in connection with its associated strata, presents the following section:

FIG. 64.



Section at Dunkin's Coal-mine, Flank creek.

- No. 6. Yellow and reddish shales, exposed, 5 feet.
- No. 5. Soft, micaceous sandstone, imperfectly exposed, 2 feet.
- No. 4. Blue shales, ferruginous below, 9 feet.
- No. 3. Slightly calcareous, indurated, bituminous shales, with fossils, 2 to 4 feet.

No. 2. Lacona coal, 20 to 30 inches.

No. 1. Yellow and blue shales, resting upon arenaceous bed, exposed to bed of stream, 10 feet.

The bituminous shale overlying the coal is charged with fossils, amongst which the following species were recognized : *Productus æquicostatus*, abundant, *P. muricatus*, *Athyris subtilita*, *Leda bellastriata*, *Solenomya radiata* (?), and another small Lamellibranchiate, *Loxonema multicostata* (?), *Bellerophon carbonaria*, and a minute undetermined species of Gasteropod. The coal is of superior quality, being quite free from *pyrite* and other impurities. The bed can be easily wrought, being above the floods and accessible. The present entry reaches into the hill about one hundred feet. The bed seems to rise in a northwesterly direction, which is also indicated by the relative level occupied by the same bed at exposures above and lower down the creek.

About one mile northwest of the last mentioned locality, probably in the northwest quarter of section 33, township 75, range 22, apparently the same coal has been opened on land of Nicholas Brown, where it is reported to attain the thickness of three to three and a half feet, and is overlaid by bituminous shales as at Dunkin's mine. A mile and a half east of the latter mine, the same horizon again outcrops in the bank of the creek on Mr. Hodson's farm, (northwest quarter of section 2, township 74, range 22), but the coal is here only ten inches thick. Indeed, the members of this horizon are here so attenuated, that at first glance we might fail to recognize its real relations. But in the adjacent valley-slope the Panora coal and overlying fossiliferous limestone bands crop out, affording indubitable evidence of the identity of the lower coal with the bed seen at Anthony's and elsewhere. The bituminous shale which rests upon the coal at Hodson's bank is charged with fossils which furnish additional proof of the identity above referred to. The following species were obtained here in addition to those observed in the same stratum at Dunkin's

mine : *Hemipronites crassus*, *Chonetes Verneuilianus*, *Nautilus occidentalis*.

Again, on Whitebreast creek, and also on Cotton and Stony branches, the same beds appear at several localities, presenting, essentially, the same physical appearances before described. In the right bank of the Whitebreast, probably in the southeast quarter of section 23, township 74, range 22, a few hundred yards below the Lacona and Newbern road, we find a vertical exposure of twenty-five feet, in which the Lacona coal is seen, but it is here accompanied by some irregular deposits not heretofore observed in connection with this horizon. The exposure occurs in a sharp bend of the creek, along the right bank of which the out-cropping is bared for several yards. The coal is fifteen to eighteen inches thick, and dips gently to the northeastward. It is underlaid by light-colored clays, containing large masses of *septaria*; and immediately overlying the bed, an indurated, slightly calcareous, bituminous shale occurs which is charged with the same fossils found in a corresponding position at Dunkin's mine and elsewhere. But this layer entirely disappears at the upper extremity of the exposure, its place being occupied by a four to six-foot layer of dark-blue and grayish gritty, shales, which are overlaid by a soft micaceous sandrock and indurated arenaceous shales, and which are in turn overlaid by an exposed thickness of ten feet of variegated yellow, blue, and reddish shales. In the debris at the foot of the bluff, fragments of fossiliferous earthy limestone are found which are undistinguishable from the layers that overlie the Panora coal, indicating the presence of that horizon at a higher elevation in the slope above the bluff out-crop.

Immediately above the Lacona bridge, in the right bank of the Whitebreast, six feet above the bed of the stream, a six-inch layer of rotten coal out-crops, which is doubtless the representative of the bed last described at the locality a few hundred yards below the present exposure. The bituminous shale is wanting here, and the micaceous sandstone presents

a bed six feet in thickness and is overlaid by an indurated argillo-arenaceous rock similar to that found in the same position in the exposure at the lower locality. In the slope, upon the east side of the creek, shales and soft sandstones are imperfectly exposed, but no indication of the presence of the Panora coal was observed, although it probably exists here. On Stony branch, in the southwest quarter of section 34, township 74, range 22, the Lacona coal is found low in the bank of the stream, where it is some eighteen inches thick, overlaid by bituminous shales and soft, micaceous sandstone. Half a mile below, at Howell's coal-bank, the coal out-crops at the water-level. At this point, a small quantity of coal has been dug from the bank, but no regular working has been begun in the bed. The sandstone above the Lacona coal is often sufficiently firm to answer for underpinnings and walling up of wells. On Mr. D. S. Myers' farm, a short distance below Howell's coal-bank, the sandstone has been quarried, to some extent, for building stone. High up the course of Stony branch, in Lucas county, the same horizons are met with at intervals, which are mentioned under the head of that county.

Half a mile south of Lacona, on the south side of Cotton creek, the Panora coal has been opened at an elevation of about thirty feet above the bed of the stream, and is reported to be above twenty inches thick. The fossiliferous limestone layers, which constitute so persistent a feature of this horizon, are imperfectly exposed at several places in this vicinity, their outcrops always agreeing with the level occupied by the coal-bed to which they everywhere hold the same relation.

In the foregoing pages we have purposely confined our observations to the lower-division of the Middle coal-measures, which we have traced from the northwestern to the southeastern borders of the county. It now remains to mention a few localities in the middle and upper divisions to complete the brief summary of the local peculiarities presented by this most interesting formation within the limits of Warren county.

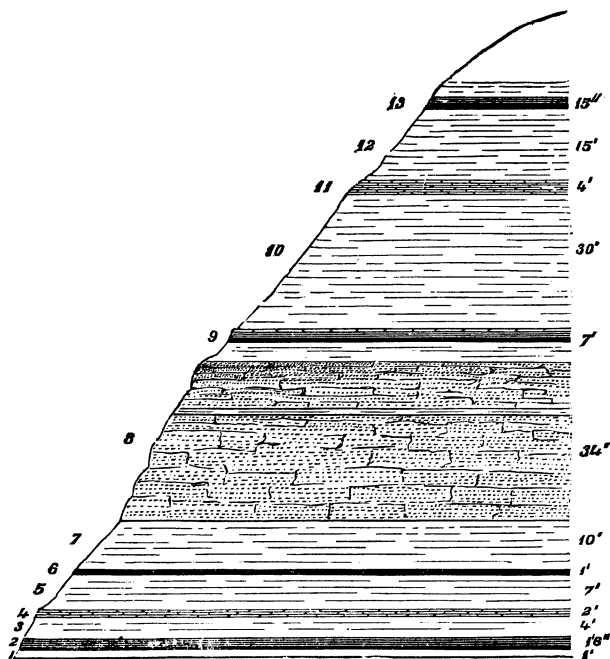
A short distance below Lawrenceburg, in the right bank of Otter creek, a coal-bed about one foot thick outcrops two or three feet above the water-level, upon which rests some thirty feet of clays and micaceous shales. Less than a hundred yards below this exposure, at the ford, the fossiliferous limestones associated with the horizon of the Panora coal rise to view above the bed of the creek, but the coal was not discovered. The bed at the upper exposure belongs to an irregular or locally developed deposit above the Panora coal, which is designated as the Wheeler coal, and though it here presents an excellent quality of coal, it is too thin to work profitably. The Panora coal may, doubtless, be reached by boring, and it seems not improbable that the coal next below that bed, or the Lacona coal, may be found at a depth of twenty to thirty feet at the ford. The latter bed, however, is so variable, thickening and thinning even in short distances, that it is impossible to say with certainty where it exists or where it has entirely thinned out. The southerly dip of these strata continues as we ascend the valley of Otter creek, which brings down the lower carbonaceous horizon of the upper-division to the water-level a mile and a half above Lawrenceburg. In the adjacent hill-sides the Upper coal-measures appear, presenting one of its most peculiar and best known horizons, the "Cryptacanthia bed," at an elevation of seventy feet or thereabout above the stream. These exposures occur in section 17, township 74, range 23, on lands of Mr. Wm. Cole, who informed us of the occurrence of a sixteen inch coal deposit in connection with the lower carbonaceous horizon in the upper-division. The bed is overlaid by the usual cap-rock of impure limestone which is abundantly charged with the fossils common to the layer.

Following down the beautiful little valley of Otter creek, whose eastern margin is limited by low sparsely wooded bluffs, while the opposite rises in more gradual ascents to the undulating upland prairie, between this stream and Squaw creek, the next rock exposures which were examined, outcrop

in the numerous ravines that intersect the upland in the vicinity of Hammondsburg. The lowest strata met with at this locality belong to the middle beds of the middle-division, passing upwards to the uppermost beds of the upper-division, affording a vertical section of above one hundred feet. On lands belonging to Mr. Sanford Brown, in the northwest quarter of section 9, township 75, range 23, a fine exposure may be seen in a ravine tributary to Otter creek, which exhibits the Marshall coal and an unusually exaggerated development of the sandstone which marks the dividing line between the middle and upper divisions of the formation. The exposures also derive some interest from the occurrence of a thin seam of coal in connection with an irregularly developed carbonaceous shale underlying the horizon of the Marshall coal, and also by the

FIG. 65

Section at Hammondsburg.



presence of a considerable thickness of the upper-division in the imperfectly exposed slope above the sandstone. The data obtained from the examination of this exposure are given in the preceding section, in which is included the Lonsdale coal, as it appears high in the sides of the ravines a short distance west of the village, presenting a general view of the strata exposed at this locality:

- No. 13. Lonsdale coal, 15 inches; overlaid by fossiliferous bituminous shales.
- No. 12. Shales, probably 15 feet.
- No. 11. Thin bedded limestone, 2 to 5 feet.
- No. 10. Yellow, red, and blue shales, 30 feet.
- No. 9. Coal, 10 inches, overlaid by black shale and impure limestone.
- No. 8. Soft, heavy-bedded sandstone, 34 feet.
- No. 7. Yellow arenaceous shales, 10 feet.
- No. 6. Marshall coal, 1 foot.
- No. 5. Light-blue shales, 7 feet.
- No. 4. Thin-bedded fossiliferous earthy limestone, 2 feet.
- No. 3. Blue shales, 4 feet.
- No. 2. Bituminous shale and thin seam of coal, 18 inches.
- No. 1. Blue shales, exposed 1 foot.

That portion of the above section, including Nos. 1 to 11, is seen in the vicinity of Brown's quarry and limekiln. The lowermost bituminous shale (No. 29. General section of Middle Coal-measures) is here accompanied by a two inch seam of coal, which, though unimportant, is interesting from the fact that it is the only known instance of the deposition of coal in this horizon which is not a persistent member of the formation. The limestone layers of No. 4 are charged with *Productus muricatus*, besides *P. æquicostatus*, *Chonetes mesoloba*, *Athyris subtilita*, *Spirifer cameratus*, *Zaphrentis*. The Marshall coal, No. 6, is known at two or three different exposures, where it shows a persistent bed of one foot of beautiful light coal. The sandstone, No. 8, is quite variable in thickness, at some exposures the lower portion is represented by arenaceous shales and only the upper five or ten feet are massive. At Brown's quarry it assumes the appearance represented in the section—a heavy-bedded, soft, reddish

sandstone with a two-foot layer of shale in the upper portion. This rock has been quite extensively quarried in the vicinity of Hammondsburg; a large part of the stone used in the construction of the Court-House in Indianola, was obtained from these quarries. Generally, however, it makes an indifferent material for building, and great care should be exercised in selecting the stone for such purposes. The lower carbonaceous horizon in the upper-division, No. 9, is well exposed in the northeast quarter of section 14, where the bituminous shales rest upon a ten or twelve inch coal-bed, and are overlaid by a thin band of impure limestone containing great numbers of *Productus muricatus*, a fossil usually rarely found in this stratum. The limestone bed, No. 11, is seen in nearly all the ravines, its outcrop usually being marked by shelly fragments of the rock which strew the slope. It makes a strong though rather dark lime, and is sometimes quarried for building stone. It contains comparatively few well preserved fossils at this locality, among which were noticed *Productus æquicostatus*, *P. Nebrascensis*, *Athyris subtilita*, *Helodus* (sp. undet.) In a ravine a few hundred yards west of the village, in the northwest quarter of section 14, on lands belonging to Mr. R. M. Hightower, (to whom we are indebted for valuable information respecting the location of rock exposures in all portions of the county), a bed of coal, fifteen inches in thickness, outcrops at one or two places, where it is accompanied by an overlying bituminous shale containing numerous fossils, of which the following forms have been identified: *Productus muricatus* common, *Athyris subtilita*, *Pleurophorus* (?), *Allorisma*, *Bellerophon carbonaria*. This horizon is probably referable to the Lonsdale coal, although the fossils are not as abundant here as at the typical locality in Guthrie county; but the general character of the outcrop is not essentially different.

In the extreme southwest corner of the county, one and a half miles northwest of New Virginia, in the banks of Limestone creek, a limited exposure of the lower carbonaceous horizon of the upper division may be seen, in which a fourteen inch

coal-bed appears. The coal rests upon blue shales, and is overlaid by three and a half feet of bituminous shale, capped by a bluish, impure lime-rock from eight to eighteen inches thick. The bituminous shales contain a few fossils, as also does the limestone. The following species were recognized in the former: *Lingula Aviculopecten*, *Beyrichia Americana*, *Petrodus*; and in the latter: *Martinia planoconvexus*, *Chonetes me. ol. ba*, *Productus longispinus*, *Allorisma*, *Bellerophon crassus*. The coal is of good quality for blacksmith's use, but in consequence of the thinness of the bed it has never been regularly opened.

Upper Coal Formation. This formation occupies a comparatively limited area in Warren county. Its eastern border crosses the extreme southwest township, probably trending eastward from New Virginia through the southern tier of townships, half-way across the county, and thence southward into the adjoining counties of Clarke and Lucas. However, outliers of Upper coal-measure strata are found in the more central portions of the county, but it is believed that these patches are not continuously connected with the main formation, they are probably remnants that have escaped the denuding agencies which swept away the bulk of the formation in its eastward extension over the county.

One of the supposed outliers is met with in the neighborhood of Lawrenceburg, which was incidentally referred to in the notice of the middle coal strata that also appear at that locality. The exposure occurs in the hill-side bordering the east bank of Otter creek in section 17, township 74, range 23, where a four foot ledge of light gray, fragmentary limestone makes its appearance at an elevation of about seventy feet above the stream. The lithological characters of the bed, no less than the organic remains which abound in the rock, indicates its identity with a well known bed in the Upper coal-measures, the "Cryptacanthia bed" of the Winterset section. The following species of fossils were found in considerable abundance at this locality, and strongly recall the palæontological appearance of the horizon at other

and more or less distant localities in adjoining counties : Crinoidal remains, *Orthis carbonaria*, *Athyris subtilita*, *Spirifer cameratus*, *Martinia lineatus*, *Retzia punctilifera*, *Productus longispinus*, *Waldheimia* (?), *Cryptacanthia compacta*, *Syntrielasma hemiplicata*, *Tomoceras Gillianum*, and two or three other species of *Gasteropoda*. The rock is too fragmentary, as a general thing, to be valuable for building purposes, but it is said to produce a good quality of quick-lime for which purpose it has been considerably quarried.

About two miles west of the village of New Virginia, on the head waters of Limestone creek, one of the lowermost calcareous horizons of this formation shows itself in the bed of the stream, presenting a four foot bed of rather compact, bluish gray, earthy limestone, in five or six layers, separated by thin, shaly partings, in which the following fossils are abundantly found: *Fusulina cylindrica*, crinoidal remains, *Rhynchonella Uta*, *Orthis carbonaria*, *Athyris subtilita*, *Spirifer cameratus*, *Spiriferina Kentuckensis*, *Martinia planoconvexa*, *M. lineatus*, *Retzia punctilifera*, *Hemipro-nites crassus*, *Productus longispinus*, *P. costatus*, *Platyceras* (?) (sp. ?), *Bellerophon crassus*. The durability of the stone for building purposes, and the facility with which the bed is quarried, renders this exposure of much importance to the country round about.

The Upper coal-measures may, and probably do, extend to the eastward of the Lawrenceburg locality, in the divide between the Whitebreast and Otter creeks. But no exposures of these strata in this region came to our notice, though they may possibly outcrop in the ravines on the head waters of Wolf creek.

Economical Geology—Coal. Warren county is well supplied with mineral fuel. The heaviest deposits of coal are those belonging to the Lower coal-formation, and which are mined to a more or less considerable extent at several points in the northeastern portion of the county. The Lower coals, however, are not of a uniform economic value, although for ordinary purposes as a fuel they will continue to supply

a steadily increasing demand as the manufacturing interests of the county become more fully developed. Beneath the beds that outcrop at the surface in this portion of the county, there are doubtless other and perhaps even thicker deposits of coal, which may be reached by shafting as soon as the demand shall warrant the expense and risks incurred in making such practical explorations. The knowledge we possess at the present time regarding the distribution of the lower coal deposits, is insufficient to enable any estimates approaching accuracy to be made as to the position and occurrence of these beds at localities distant from their known outcrop. But that such deposits do exist beneath the beds already known in this region, there can be no doubt, and the depth at which they may be encountered can only be determined after a detailed study of the formation to which they belong, or by the more expensive alternative of practical exploration, by means of boring and shafting. Boring for coal so often proves unreliable in the data thus obtained, but, in a region where we are pretty sure underlying deposits occur at moderate depths beneath the surface, shafting generally turns out to be the most economical method for making these explorations.

The Middle coal formation also possesses several coal horizons, some of which are of sufficient thickness for working on an extensive scale. As a rule, the coals of this member of the coal-measure series are remarkably free from impurities, and for many purposes it is far superior to the average product of the beds in the Lower formation. There are six coal beds in this formation, three of which are persistent. The lowermost bed, though it is not a persistent horizon, is usually the best developed bed in the formation, locally reaching a thickness from three to four feet, as in the region about Lacona, from which locality the bed receives its name. The thinner beds, where their outcrop is favorable, are usually worked by stripping off the overlying deposits, and the coal taken out as in quarrying. But as yet none of these coals have been worked to any considerable extent in the county.

No coal beds are known in the Upper coal-measures in the county. The aggregate thickness of the coal deposits found in Warren county is somewhere in the vicinity of fifteen feet. Of these there are at least four workable beds, two in the Lower and two in the Middle formation. There is no portion of the county where the Lower coal-measure deposits may not be reached at the depth of one hundred to three hundred feet from the surface in the valleys, and over much of its area even at less depths.

Building Material. Good building stone is not abundant in the county. Both the Lower and Middle coal formations afford sandstones; but these beds are generally soft and shaly, and it is necessary to use much care in selecting the rock when it is designed to be used in permanent structures. However, some of these layers are said to harden after removal from the quarry, and being soft when first quarried, the stone is easily fashioned into any desired shape. Probably the most extensive sandstone quarries are those in the vicinity of Hammondsburg. There are other quarries near Sandyville, and in the right bank of Squaw creek, four to six miles above its mouth, extensive exposures of Lower coal-measure sandstone occur, portions of which may prove to be valuable for building purposes. Limestone is much less abundant than sandstone, and beds sufficiently pure for making quick-lime have been found at but few localities. The limestone bands in the middle coal formation seldom furnish a durable building stone, owing to the facility with which they disintegrate from exposure. Earth for the manufacture of brick is found in all portions of the county, and from the fact that the county is well supplied with both wood and mineral fuel, the deficiency of rock suitable for building purposes is more than compensated by the cheapness with which a good quality of brick may be supplied.

No valuable deposits of iron are known to occur in the county, although ferruginous nodules are not unfrequently met with in the coal-measure shales. The economic

importance of these formations in every other respect is inestimably subordinate to the coal product.

9. LUCAS COUNTY.

Lucas county lies in the second tier of counties north of the Missouri State line, and embraces twelve townships, or an area of three hundred and eighty-four square miles. It lies immediately south of Warren and Marion counties, and is bounded on the east by Monroe, west by Clarke, and on the south by Wayne county.

General Surface Features—Drainage. The southern tier of townships is watered by Chariton river, which takes its rise a few miles to the westward in the adjoining county of Clarke. The principal portion of the county is drained by affluents of the Des Moines river, several of which take their rise within its borders. The principal one of these is Whitebreast creek; the others are the North and South Cedar creeks, English Little Whitebreast, and Otter creeks. The drainage of the two northern tiers of townships flows to the northward, while that of the southern tier reaches the Missouri through Chariton river. There is hardly a county in the State that has a more complete system of watercourses—every township being traversed by one or more of the principal streams mentioned above, besides numerous tributaries which intersect the uplands in every direction, affording abundant supplies of water.

Surface Configuration. Situated upon the Great Watershed of the State, which crosses the county in a general east and west course, its topography differs in some respects from that of the counties upon the lower courses of the streams which have their sources in this region. Although the Watershed divide in this part of the State does not form the highest land between the Mississippi and Missouri, which indeed lies wholly within the Missouri drainage area several miles to the westward in Union county, it still comprises one of the most elevated portions of the county, attaining in the

vicinity of Chariton, an elevation of about one thousand feet above tide-water. This tract comprises a narrow strip of comparatively level land, whose steeper declivity faces the south along Chariton river; that is to say, the general slope is more gradual upon the northern side of the watershed than it is to the southward, which doubtless is attributable to the presence of numerous small streams which take their rise upon that side of the divide. The Chariton winds along the southern foot of the divide, receiving but few tributaries upon its north bank, while on the opposite margin several important affluents gain the stream, the largest of which in this county is Wolf creek. Even the subordinate divides that form the uplands between the streams that flow into the Des Moines, possess in a greater or less degree, the same features common to the Great Watershed: they are beautiful tracts of undulating or nearly level prairie, possessing a black, fine soil, and mantled with luxuriant herbage. On approaching the watercourses, the uplands become broken and furrowed by deep ravines which are not unfrequently occupied by dense growths of young forests.

The valleys are, in all cases, well marked, being defined by more or less abrupt upland declivities upon either one or other margin and sometimes upon both. But it is more usual to find the slope upon one side of the valley less abrupt than that upon the opposite, although along the smaller streams this peculiarity is not noticeable, both sides being bounded by steep bluffs, which rise from the narrow interval lands immediately bordering the streams. The larger streams have excavated their valleys to the depth of two hundred feet, and along portions of their courses fine alluvial tracts are found. These bottom-lands, however, constitute but an inconsiderable area compared with that embraced in the uplands. They are subject to annual or periodic inundation from freshets, so that they have not been resorted to for agricultural purposes, even proportionally to the same extent as have the upland prairies, which are being rapidly improved by a class of intelligent and thrifty agriculturists. The valley

of the Chariton is occupied by a low, wet bottom, varying from a quarter to half a mile in width, and valuable at the present day mainly for the grasses it produces. Although the bottoms on the Whitebreast are also subject to overflow, there are considerable tracts of cultivated land, besides bodies of valuable timber.

As was observed in reference to the valleys in Warren county, terraces of marked conformation are rarely seen along the streams in this county. It would appear that the absence of these formations in the valleys in this region is due to the fact that the materials which enter most largely into the composition of terraces do not exist here in the same abundance as in the counties to the northward, where these formations display their most characteristic and pleasing features. All the streams have eroded their beds deeply into the subjacent strata of the coal-measures which form the greater portion of the bordering upland slopes upon which very little coarse material of the Drift Deposits remain; and the fine sediments derived from the disintegration of the coal-measure shales do not seem to have afforded the proper materials for the formation of terraces. However, in the valley of Whitebreast creek, near Wheeler's mill, in Liberty township, there exists what was once a wide flood-plain that stretched across the valley from the east side occupying a considerable portion of its area at this point. The bench has an average height above the present level of the stream of about thirty feet. It is apparently in part made up of an outlier of undisturbed Middle coal-measure strata, and in part by fine deposits of the river. At the time of its formation the stream flowed along the western margin of the valley, its old bed being distinctly traced and even yet occupied by the stream in high water. But at a subsequent period the stream shifted its channel to the east side of the valley, cutting through the terrace and exposing a limited thickness of the Middle coal-measures near the present site of Wheeler's mill. The streams themselves are margined by steep, muddy banks, and their current is more or less turbid from the

amount of fine sediment held in suspension by the waters, in this respect resembling the streams throughout the southern extension of the coal-field.

Springs do not occur frequently, though they appear occasionally in the valley-slopes. In an early day, "deer-licks" were known at various places, but these have gradually disappeared as the country has become settled, and the reported salt or brine springs are no longer to be found, even if they exist.

Soil. In the valleys we invariably find a deep, fine soil, highly charged with humus. The adjacent uplands have contributed greatly towards enriching the valley deposits, and in many cases the border slopes are almost entirely denuded of their humus charged soil, presenting in such situations large patches of yellow clay soil. Indeed the subsoil over the larger portion of the uplands is of a decided argillaceous character, which was probably derived from the disintegration of the coal-measure shales. Wherever the Drift Deposits occur to any considerable extent, the surface soil is more porous and less liable to become unmanageable in wet seasons.

Forests are well distributed over the county, occurring mainly along the streams, and often densely wooding the more broken lands of the border uplands. It is a noticeable fact that, along that portion of the streams having an east and west direction, the densest growth of timber is found upon the south side, while the opposite slope may be quite destitute of trees. The varieties of trees here found are the same as those mentioned as commonly found in Warren county. The growths are small, but there seems to be ample for the present necessities of the inhabitants.

Geology. The superficial or Post-tertiary deposits and the coal-measures comprise all that is to be seen at the surface of the geological structure of the county. Of the coal-measures, probably all three of its formations exist here, but the Middle coal-measures outcrop over the larger area; the Lower coal-measures occurring in the eastern portion of the county,

while the upper formation is only known by a single exposure, although this member doubtless, underlies a considerable portion of the western and southwestern townships.

Post-tertiary. The Drift deposits, although generally distributed over the county, do not present a conspicuous feature in its geology. These deposits are made up of blue and mottled clay charged with gravel and boulders, and outcrop rather high in the valley-slopes. In the high prairies they are seldom seen, if indeed they are present at all, which also explains the infrequency of boulders and gravel in those situations. Red quartzite is found associated with boulders of gneiss, granite, and porphyry, which have accumulated in the beds of the ravines in considerable numbers at some points. The gravel beds which constitute so important a part of the Drift in other portions of the State, are but slightly developed here. In their place, however, we meet with local deposits of sand in the margins of the valleys, which are apparently the result of the wearing away of the sandstones and arenaceous beds of coal-measures, and the re-arrangement of the material by the waters in the early stages of the draining of the surface subsequent to the Glacial epoch.

Coal-Measures—Lower Coal Formation. This formation occupies an irregular tract in the eastern portion of the county, comprising portions of townships 72 and 73, range 20, and probably extending westward into township 72, range 21, near the center of the county. The limits of its western outcrop, however, are not perfectly known, but it is known to exist in the before mentioned townships, or Pleasant, Cedar, and Chariton, and also a limited area on the northern border of the county in Liberty township, (township 73, range 22).

In the northeast corner of the county, on a branch of the North Cedar, known by the name of Flint creek, at Cole's mine, a three-foot coal-bed shows itself in the right bank about fifteen feet above the stream. The coal rests upon light blue shales, and immediately overlying the bed is a

five-foot layer of black, bituminous shales, capped by an irregular, thin band of dark bluish limestone, with *Productus muricatus*, showing a thickness of strata about ten feet. A thin seam of pyritiferous shale divides the coal into two layers of nearly equal thickness; with this exception the coal is comparatively free from impurities. The outcrop of the bed at this locality is very favorable for extensive mining, and already an entry has been driven several yards into the bank, the coal being delivered upon the opposite side of the creek by means of a trestle. Two hundred yards below Cole's mine the same bed again appears in the left bank, at about the same elevation above the creek, and presenting the same appearances as at the former exposure.

A few hundred yards above Cole's mine in the bed of Flint creek, at the ford, we find an imperfectly exposed coal-bed two feet, more or less, in thickness, which is immediately overlaid by a one-foot layer of conglomerate or pudding-stone, cemented with ferruginous material, and above this ten feet of grayish, blue, coarse sandstone, with obliquely laminated layers, giving an exposure of from ten to fifteen feet in thickness. The coal is traversed and interrupted in its continuity by seams and wedge-shaped masses of *pyrite* and indurated pyritiferous shale, which renders it worthless for any practical purpose. Higher up the creek the sandstone crop out in the banks where good quarries may be opened with little labor. At the ford, the beds have a slight southeasterly dip down the stream, but their relative position to the lower exposures could not be satisfactorily determined, though it is thought probable that this bed overlies the coal horizon seen at Cole's mine.

On Mr. J. A. Rudisell's farm, in the northwest quarter of section 10, township 73, range 20, sandstone outcrops in the hill-sides and in the bed of a branch of Second creek, which is probably the equivalent of the rock last described. A short distance above Mr. Rudisell's, coal has been discovered on Second creek, in the southwest quarter of section 10, which is doubtless referable to the bed exposed at Cole's mine, on

Flint creek, two miles to the northeastward. This locality, however, has not been developed and the thickness of the coal was not ascertained. Three miles due south of Rudisell's, near the steam-mill on the North Cedar, coal has been worked to a more or less considerable extent for several years. The mine is situated some distance above the mill on the west side of the valley, in section 27, township 73, range 20, on the Fowler estate. At the time of our visit the entry was filled with rubbish and water, in consequence of which no measurements were made. The coal is reported from three to four feet thick, and is overlaid by a few feet thickness of carbonaceous shales and dark blue clays. Half a mile below the mill, also in section 27, a three foot bed of coal is known, which is doubtless the same as that seen at the above exposure, and which may prove to be identical with the bed at Cole's mine mentioned above.

No rock exposures were met with on the north Cedar, above the last mentioned locality. But crossing the intervening divide, over a fine, upland prairie, in the valley of the Little Whitebreast, in the vicinity of Thompson's mills, between two and three miles northeast of Chariton, several workings have been opened in a coal-bed, low in the valley from which quite large quantities of coal have been taken. The only exposure showing any considerable thickness of the associated strata, is that seen in the right bank of the stream just above the mill, where a fifteen to twenty-inch coal bed outcrops ten feet above the creek. Between the coal and the water level, bluish and light-colored shales occur, while above the coal, some fifteen feet of dark blue shales, capped by twelve feet of blue and yellow arenaceous shales are found. The coal is immediately overlaid by an irregular layer of pyritiferous nodules, which at some places affords a few fossils—*Bellerophon* and *Pleurotomaria*. Entries have been driven into the coal at several places in this vicinity, the bed ranging from twenty to thirty inches, and yielding an average quality of coal. The strata have a general southwesterly

inclination, which is locally equal to five feet in the distance of thirty-five yards. The principal mines are located in the following numbers of land : Pearson's mine, northwest quarter of section 15 ; Paine's mine, southwest quarter of section 10, coal two feet thick ; northwest quarter of section 9, coal two feet thick ; Thompson's mine, northeast quarter of section 16, coal fifteen to twenty inches ; and other banks higher up the course of the Little Whitebreast, in sections 22 and 27, all in township 72, range 21, or Chariton township. There is some doubt as to the relative position of this coal horizon. It bears a somewhat striking resemblance to the lowermost or Lacona coal in the Middle coal-measures, and this resemblance is enhanced by the appearance of arenaceous deposits a few feet above the coal, as shown in the exposure at Thompson's mine. But no indication of the presence of other and well known strata belonging to the lower division of that formation were observed at this locality, therefore, the present coal-bed is provisionally referred to the Lower coal-measures.

On the east side of the Little Whitebreast, three miles in a direct course below Thompson's mills, other and very similar exposures are met with. One of these may be seen on a small branch in the northeast quarter of section 32, township 73, range 21, showing a thin bed of coal from one and a half to two feet in thickness, at an elevation of perhaps thirty feet above the main stream. One to two feet of bituminous shales immediately overlie the coal, and above this bluish, yellow shales, apparently passing upward into a soft, yellow sandstone, which outcrops in the slopes ten to twenty feet above the coal-bed. The sandstone has been quarried on Mr. Winshall's land adjoining, where the bed is about five feet thick. Below the Chariton and Newbern bridge, several openings have been made in the coal-bed, on the east side of the Little Whitebreast, on lands belonging to Branaman, Brown, Vanway, and others, in sections 29 and 30, none of which, however, were being worked.

There is a limited area in the northeast corner of Liberty

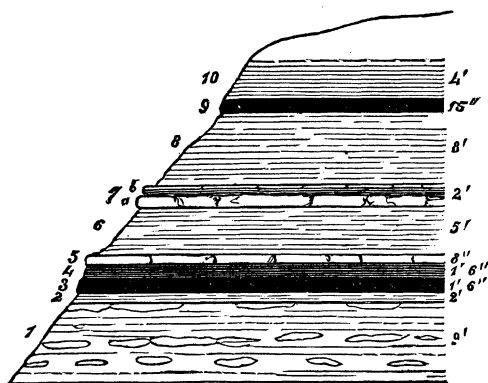
township, in which these strata outcrop, displaying at one or two points a two to three foot coal-bed. The most satisfactory exposure of the bed is that at the mine on Wm. Grave's land, in the southeast quarter of section 1, township 73, range 22. At this place an entry has been driven into the bed from the bed of the ravine, and at different times considerable coal has been mined. The coal rests upon light blue clays, and above is found a band of dark fossiliferous shales, overlaid by an exposed thickness of about ten feet of bluish, ferruginous clays, passing upwards into soft, arenaceous, and micaceous shales. The dark shales immediately resting upon the coal, afford the following fossils: *Lingula*, *Myalina* ———, *Aviculopecten rectilateraria*, *Loxonema multicostata* (?), *Orthoceras*. This coal-bed, doubtless, can be found with little trouble in all the neighboring ravines, and so far as we were able to judge, the coal is of fair average quality. In the northwest quarter of section 1, a coal-bed has been wrought in the bed of Whitebreast creek, which is said to attain three feet in thickness. This outcrop is on Mr. N. N. Webb's land, and it is only during the lowest stage of water that the bed is exposed at all. It may possibly belong to the same horizon as that at Grave's mine. The strata have apparently a southwesterly inclination, and in the distance of a few miles the Lower coal-measures disappear beneath the level of Whitebreast creek, and do not again appear at the surface in that direction.

The Middle Coal Formation first appears on the Whitebreast in this county, about three and a half miles above the confluence of the Little Whitebreast, on Mr. Halferty's land, where are found the fossiliferous limestone layers overlying the Panora coal of the lower division of the formation. The coal, however, is not exposed at this locality. But in the southeast quarter of section 28, township 73, range 22, this coal horizon is finely displayed, giving a vertical section of about twenty feet in the right bank of the stream, on lands of S. D. Wheeler. The Panora coal occupies a

level about ten feet above the creek at this place. Half a mile or so above in the immediate vicinity of Wheeler's mill, the same beds are again observed, but here the Panora coal is on a level with the water, indicating a slight southerly or, more probably, southwesterly dip of the strata. This exposure is in the northeast quarter of section 33, and on Halfway branch a few hundred yards below the mill the same strata are in part exposed, occupying a slightly higher level than at the mill. This locality derives unusual interest from the presence of a second coal-bed but a few feet above the Panora coal, which is entirely absent in the northern extension of the formation, but which, in this region, seems to be well developed and to have quite a wide distribution. From the fine development of this coal at this locality, where its relative position was first recognized, we have designated this bed as the Wheeler coal in the General Section of the Middle coal-measures. The lower or Panora coal at this locality, presents a thickness of from one to one and a half feet; the upper or Wheeler coal was found from fifteen to twenty inches thick. At the lower exposure, in section 28, both beds have been worked to some extent; the coal is said to be very good in quality. The exposure at the mill appears in an abrupt bank formed by the cutting through

FIG. 66.

Section near Wheeler's mill, Whitebreast creek.



of a terrace by the stream, and exhibits a more satisfactory section of the upper strata than that found at the former exposures. The preceding section exhibits a view of the strata exposed at this locality:

- No. 10. Mottled blue and yellow shales, 4 feet exposed.
- No. 9. Wheeler coal, 15 to 20 inches.
- No. 8. Mottled blue, and yellow shales, 8 feet.
- No. 7. Grayish, impure limestone, in two layers, 2 feet.
- No. 6. Blue shales, 5 feet.
- No. 5. Hard, brittle, bluish limerock, 8 inches.
- No. 4. Bituminous, fissile shale, 18 inches.
- No. 3. Panora coal, 12 to 18 inches.
- No. 2. Blue shales, 1 to 3 feet.
- No. 1. Yellow, gritty shales, with nodular bands, exposed to water level at the lower out cropping, 9 feet.

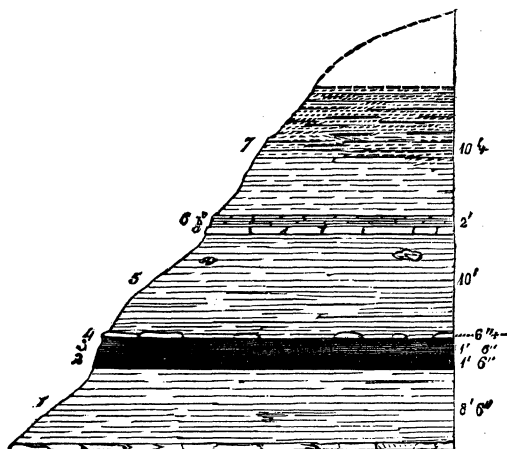
The bituminous shales, (No. 4), contain small rhombic scales probably belonging to the Ganoid genus *Palæoniscus*, and *Petrodus* and spines. No. 5, a very brittle impure limestone, crumbling in pieces from exposure, contains the following fossils: *Productus muricatus*, *Rhynchonella Uta*, *Martinia planoconvexa*. No. 7, is a fragmentary earthy limestone. (7a) The lower layer, contains in abundance *Productus muricatus*; and, in the upper layer, (7b) *Martinia planoconvexa* is the prevailing fossil. The persistency with which these layers retain their palæontological characters, over so considerable an area, is no less remarkable than their uninterrupted continuity throughout the geographical extent of the formation in Iowa. Four miles above Wheeler's, in a southwesterly direction, in the neighborhood of Yost and Hunt's steam-mill, two or three small workings have been commenced in a coal-bed, which is probably one or other of the beds last described. The coal outcrops on branches of Whitebreast creek, in sections 17 and 20, township 72, range 22, but the flooded condition of the streams in the season of 1869, when the locality was visited, obliged the suspension of mining operations, and in consequence, no satisfactory examinations were made. A mile below, near the crossing of

the Burlington and Missouri River Railroad, a shaft excavation has been begun in search of coal, with what success was not ascertained. However, there can be little risk in shafting for coal at this locality, since the Lacona coal and the upper beds in the Lower coal-measures probably lie at a depth within one hundred feet of the surface of the valley; and at still greater depths the heavier deposits of the latter formation will be successively passed through in boring for coal at this locality. But as we ascend the valley of the Whitebreast these beds, doubtless, lie at greater and gradually increasing depths beneath the surface.

On English creek, in the northern portion of the county, several coal-mines have been opened in the Panora coal, presenting, essentially, the same appearances observed in connection with this bed at Wheeler's and elsewhere. The lowermost exposure seen on the creek within the county, is that at Farley's mine, in the southeast quarter of section 10, township 73, range 21, where the most complete section was obtained, as represented by Fig. 67, and the following description:

FIG. 67.

Section at Farley's Coal-mine, English creek.



No. 7. Yellow, arenaceous shales, imperfectly exposed in slope, 10 to 15 feet.

No. 6. Earthy, yellowish gray limestone, in two layers with clay partings, 2 feet. The lower layer is 8 to 10 inches thick, and is abundantly charged with *Productus muricatus*; the upper layer forms a thin band, in which great numbers of *Martinia planoconvexa*, occur. Above this, there is a thin irregular layer of limestone which is crowded with *Chonetes mesoloba*, *Productus æquicostatus*, besides *Hemipronites crassus*, *Athyris subtilita*, *Spiriferina Kentuckensis*, etc.

No. 5. Blue shales, with *Septaria* in upper part, 10 feet.

No. 4. Irregular or nodular band of impure, bluish gray limestone, 6 inches.

No. 3. Black, carbonaceous fissile shale, with *Petrodus* and spines, 18 inches.

No. 2. Panora coal, 15 to 20 inches.

No. 1. Light colored and bluish shales, resting upon a bed of indurated argillaceous rock, seen in bed of stream, 8 feet.

The entry reaches several hundred yards into the hill, and considerable quantities of very good coal have been taken from the mine. The bed varies from fourteen to twenty inches in thickness, and dips slightly to the southward.

Three quarters of a mile above Farley's mine, on Mr. David Ballard's farm, in the southeast quarter of section 15, the same bed shows itself two or three feet above the bed of the stream, where it is only eight inches thick. But higher up the West English, the bed outcrops at two other places in the bed of the stream, in sections 15 and 21, where it has a thickness of fifteen to twenty inches. On East English creek, other exposures of this coal horizon were examined, and at one or two places in sections 11 and 14, entries have been excavated into the bed, and considerable quantities of coal mined. The Wheeler coal is not shown in any of the above exposures, although it doubtless might be found in favorable locations in the hill-sides. But the soft nature of the shales in which this bed is enclosed, readily obscures its outcrop, except at a few favorable exposures where the strata outcrop in steep banks rising immediately from the water's edge. However, it is by no means improbable that the Wheeler coal may be wholly wanting at this locality, since we know it is absent in the counties to the northward, where this formation presents its most persistent characteristics in all other respects. It would be comparatively inexpensive to make

explorations which would furnish satisfactory evidence, one way or other, as to the existence of this coal-bed in the English creek region. If it exists at all, it will be found doubtless in the slope fifteen to thirty feet above the lower bed, whose outcrop is already well known at Farley's and Ballard's, etc.

On the northern border of the county we find an interesting exposure of strata which bear a striking resemblance, if indeed they are not identical, to some of the lower calcareous beds in the Upper coal-measures. These beds may be seen on Long branch, a tributary of English creek, in the northwest quarter of section 3, township 73, range 21, at the limestone quarries on lands belonging to Mr. John Graves and Mr. L. Smith. The exposures consist of a light gray limestone, overlaid by thin bedded, earthy, buff limestone, with calcareous, shaly partings, showing a thickness of four feet. The limestone makes a very excellent quality of quick-lime, for which purpose it is quite extensively quarried. The lithological and palæontological characters of the rock have a very decided Upper coal aspect; containing in abundance, species which are very rarely found in the Middle coal-measures. Among these forms may be cited: *Meekella striatocostata*, *Waldheimia millipunctata*, *Productus longispinus*, *Chonetes Verneuillianus*, and a small Lamellibranchiate resembling *Pleurophorus*. The following species occur in addition to those just enumerated: *Athyris subtilita*, *Spirifer cameratus*, *Retzia punctilifera*, *Hemipro-nites*, *crassus*, *Productus æquicostatus*, *P. costatus*, Polyzoans, and crinoidal remains. The limestone at all its exposures bears unmistakable indications of having been disturbed; some of the ledges pitching down on end as though it had slidden in large masses or blocks from a higher position in the hill-side. Indeed the latter supposition seems to be the only satisfactory way of accounting for the presence of the bed at this locality, since but a few hundred yards above the quarries we find the well known Panora coal horizon at the same level as the limestone ledges. The latter beds

appear in the bed of a small branch of Long branch in the same quarter-section, where the coal is said to be a foot thick, and is overlaid by the fossiliferous, earthy limestone layers common to this horizon. Mr. Luther Riggs of Newbern, informed me that the same bed has been discovered at other places in this vicinity, and it or the Wheeler coal again crops out on the main branch a mile little south of west of Smith's quarry, in the southeast quarter of section 5, on lands of Mrs. Lida Seward. From the data we have here presented, it is very evident that the limestone at Smith's quarries is not in place, and it is most probable, that the bed is a remnant of the Upper coal-measures, and whose actual position in the series is probably two hundred feet above that occupied by the disturbed ledges in the banks of Long branch. We have no evidence of unconformability between the Upper and Middle coal-measures, and there seems to be no other manner of explaining the presence of the limestone at this locality than that stated above.

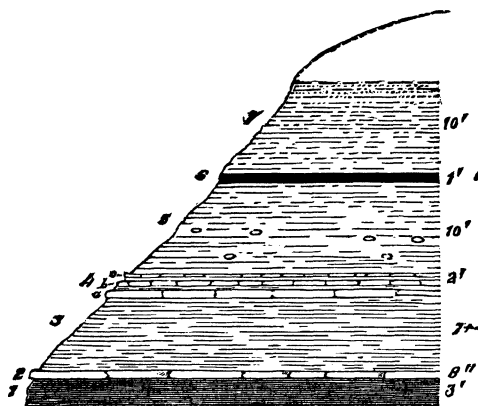
Immediately adjacent the East English, the land is quite rolling, but rising the divide to the eastward, we traverse a beautiful level prairie upland until gaining the headwaters of several tributaries of the North Cedar which rise in the divide, the surface is again corrugated, so to speak, by ridges and deep intervening ravines in which we again encounter Middle coal strata, as well as beds pertaining to the Lower measures, which have been mentioned in the preceding pages. Still lower down the North Cedar, in the adjoining counties of Monroe and Marion, the Lower coal formation is finely displayed, exhibiting several important beds of coal.

The most easterly exposure of the Middle coal-measures in the county is found on Second creek, about a mile east of Col. Walker's residence, in the northeast quarter of section 17, township 73, range 20. At this locality, the bituminous shales and nodular limestone cap-rock, associated with the Panora coal, outcrop in the banks of the creek at the ford; and a hundred yards to the northward, in the side of a ravine,

the upper layers of the lower-division of the formation are well exposed, showing the Wheeler coal which is here about twelve inches thick. The following section exhibits the relative position of the strata at the two outcroppings, and furnishes an interesting duplicate of that seen at Wheeler's mill, eleven miles distant, in a direction little south of west:

FIG. 68.

Section near Col. Walker's, Pleasant Township.



- No. 7. Yellowish, gray, slight arenaceous shales, exposed 10 feet.
- No. 6. Wheeler coal, 1 foot.
- No. 5. Light-blue, indurated, slightly gritty shales, with nodules, 10 feet.
- No. 4. Light bluish, earthy limestone, in three layers with clay parting 2 to 3 feet.
- No. 3. Dark blue shales, about 7 feet.
- No. 2. Bluish, impure limestone, 8 inches.
- No. 1. Black, carbonaceous shales, fissile, 3 feet, exposed to bed of stream.

The cap-rock, No. 2, contains but few fossils—*Productus muricatus* and *Martinia planoconvexa*. No. 4 is seen in base of exposure in the ravine above the ford. The lower layer is several inches thick; while the upper ones form thin bands from two to four inches in thickness. The following fossils are quite abundant in this bed, in the different layers of which is found the same association of species usually observed in this horizon at other and more or less distant localities: *Productus muricatus*, *P. æquicostatus*, *Chonetes*

mesoloba, *Hemipronites crassus*, *Athyris subtilita*, *Spirifer cameratus*, *Martinia planoconvexa*, *Allorisma*, crinoidal remains. The outcrop of the Wheeler coal, No. 6, is much decomposed from exposure, so that little could be ascertained regarding its character and value. The lower bed or Panora coal was not exposed to view, and, judging from the unusual thickening of the overlying bituminous shales, No. 1, it may be represented at this locality by a comparatively thin and unimportant seam.

In the southern tier of townships, along the Chariton river, no rock exposures came to our notice. It is not improbable that the Middle coal-measures immediately underlie at least portions of the southeastern townships. In Otter Creek township, in the northwest part of the county, exposures are equally rarely or never met with. On Stony creek, in the northern part of Liberty township, the Panora coal is found at one or two points, and in the bed of the stream, or low in its banks, the Lacona coal outcrops. This bed is overlaid by fossiliferous bituminous shales, identical in every respect with the horizon as it appears at intervals lower down Stony creek, within the borders of Warren county. The upper bed is said to be fifteen inches in thickness, but the abandoned and fallen-in condition of the banks, prevented any measurements being made.

The Upper Coal-measures, with the exception of the locality on Long Branch, previously referred to, are not actually known to outcrop within the limits of the county. There can be but little doubt but that the southwestern townships, are, in part at least, underlaid by this formation. Indeed it seems not improbable that these deposits may be found extending along the western border of the county, in continuation southward of the border outcrop of the formation in Warren and Clark counties. The extent of the exposures on Long Branch, in the northern part of English township, —northwest quarter of section 3, township 73, range 21—is as yet imperfectly known. The present outcroppings are quite limited, and as has been already stated, the strata present

every appearance of having been displaced from ledges originally occupying a higher position, of which, however, not a vestige remains.

Economical Geology—Coal. Lucas county possesses an abundant supply of mineral fuel, its whole area being underlaid by the productive or Lower coal-measures, whose outcrop occupies a considerable portion of the eastern half of the county. To the westward, in most of the valleys north of the Great Watershed, the same deposits of coal may be reached at practicable depths, ranging from fifty to one hundred and fifty and two hundred and fifty feet. Below the coals that appear on the Little Whitebreast and North Cedar the heavier deposits of the Lower formation occur, and which are everywhere accessible in that region by shaft mining. The aggregate thickness of the coal deposits seen at the surface, including the beds in both the Lower and Middle coal-measures, is probably not far from nine feet. The coal that is being mined in this county compares favorably in quality with the product of other localities in the west. None of the mines are at present extensively wrought, but with the increasing demand for coal, the facilities for supplying the market can be almost indefinitely increased.

Building Stone is not abundant in the county. There are but one or two limestone quarries that furnish a durable material for building, or material for making quick-lime. A couple of miles northeast of Chariton, on the Little Whitebreast, a thin bed of dark gray limestone is quarried on Mr. George Houston's place. This bed belongs to the lower division of the Middle coal-measures—Bed No. 2, General Section of Middle Coal-measures—and burns into a strong though dark lime. In the northeast corner of the county on Flint creek, a rather compact sandstone affords a tolerable building stone, and quarries might be easily opened along its outcrop for a considerable distance in the banks of the stream. Materials suitable for the manufacture of brick are abundant in all sections.

In many sections of the county, vigorous growths of young forests are found. Fruit trees are easily raised, and much fine fruit is already grown. The grape is also successfully cultivated. The broken lands afford favorable situations for orchards and vineyards, and these tracts may be turned to the most profitable account for horticultural purposes. Possessing a variety of excellent soils adapted to the growing of all crops common to the latitude, Lucas may be justly ranked with the foremost agricultural and coal producing counties in the State.

10. GUTHRIE COUNTY.

Guthrie county is bounded on the north by Greene and Carroll counties, east by Dallas, on the south by Adair and Cass, and west by Audubon county. It contains a superficial area of little more than five hundred and seventy-six square miles.

General Surface Features—Drainage. The county is almost wholly drained by Middle and South Raccoon rivers and their affluents, the principal of which are the Brushy Fork, Bear, Beaver, Willow, and Mosquito creeks. The South Raccoon rises in the watershed divide on the northwestern borders, and receives near the center of the county the Brushy Fork, which is the more important stream of the two. All three branches of the Raccoon enter the county in the northwest corner, and flowing diagonally and nearly parallel, two to four miles apart through the county, they make their exit in the southeast township. Middle river, which also takes its rise in Guthrie, waters the extreme southwest portion of the county.

The valley of Middle river is well defined, even along its upper course, and like all the streams which rise in the great divide in this region, its waters are collected by a system of numerous ravines which reach up to the very crest of the watershed. The divide between the Three river region, to which Middle river belongs, and the Raccoon rivers is a

high undulating prairie, intersected along its northern side by numerous small streams, tributary to the South Raccoon. As in Dallas county, the country embraced in this region is more broken along the watercourses than is the case in the central and western portions of the county, which are immediately underlaid by the more readily disintegrated deposits of the Middle and Lower coal-measures. In the western range of townships bordering upon the great divide separating the drainages of the Mississippi and Missouri, the prairie is rolling, presenting a wide contrast to the country to the eastward. The divides between the South Raccoon and the Brushy Fork, as well as that between the latter stream and Middle Raccoon, partake of the same physical features, being symmetrical ridges, flanked by graceful declivities, and culminating in broadly rounded summits, one hundred to two hundred feet above the valleys. The valley of Middle Raccoon is narrower, and usually bordered by more abrupt acclivities. To the eastward of the Middle Raccoon, the country sweeps away in gentle undulations which are interrupted only by the shallow prairie streams which water that section of the county.

The Soil includes two well-marked varieties, the occurrence of which is co-extensive with the distribution of the two widely diverse deposits, composing the superficial formations in this region. The uplands over the larger portion of the southwestern half of the county, afford a light, fine silicious soil which is derived from the peculiar Bluff Deposit which occupies the surface in this portion of the county. The eastern and northeastern townships possess the rich, black loam characteristic of the drift region. The native forests are confined to the valleys and ravines. But where there is the least protection from the fires which sweep the prairies in early spring and late autumn, large tracts have been clothed with a vigorous growth of oaks, hazel, etc., as may be witnessed on the uplands bordering the Middle Raccoon, near Panora and elsewhere, where even a shrub was not to be found in the early settlement of the county, ten or fifteen

years ago. The prairies in summer are clothed with nutritious herbage, affording excellent pasturage and a good quality of hay. The streams are supplied with clear water mainly derived from springs, which, however, instead of appearing at the surface, their waters percolate through the loose deposits in the valleys, and reach the streams by subterranean channels. Wells are easily obtained at most localities, but on the uplands, in the southwestern townships, the Bluff Deposit must be penetrated to the underlying gravel beds of the Drift before a permanent supply of water can be obtained.

Geology. Guthrie county presents a greater diversity in its geological structure than any county in this district. The formations found within its borders comprise those of the Post-tertiary, Cretaceous, and Coal-measures.

Post-Tertiary—Bluff Formation. In addition to the clays and gravel deposits of the Drift, which constitute so important a feature in the surface geology of the eastern portion of the State, Guthrie county is partially covered by the marly silicious deposit of the Bluff formation. This deposit occupies all the higher grounds or divides, west of the Middle Raccoon, gradually increasing in thickness on approaching the watershed divide on the western border of the county. The presence of this deposit is readily detected by the peculiar even conformation of the surface, however rolling the country may be, and the graceful curvatures of the declivities bordering the valleys. Along the extreme eastern margin of this formation its material is often so attenuated, and mixed with the gravelly clays of the Drift, as scarcely to be recognized, though it not unfrequently occurs as outliers, in the form of low mounds of only a few yards extent, resting upon the upland between the South Raccoon and North and Middle rivers.

Drift. The Drift Deposits occupy the surface in the northeast half of the county, or all the country to the east of the Middle Raccoon, and present the same composition as observed in the counties east of this. The glacial or

blue clays have been subjected to extensive although very irregular erosion, and the coarse materials thus derived are consequently very unevenly distributed in different localities. Along the east margin of the Middle Raccoon, these deposits form quite conspicuous mounds and well defined ridges, which abut close upon the valley, and descend by more gradual declivities into the shallow parallel basins of the smaller streams and sloughs, constituting one of the most peculiar features in the topography of the drift in this section. Indeed, the slope of the country to the eastward is so considerable that were it not for these dike-like barriers and similar, though less elevated intermediate ridges, the drainage would flow directly into the North Raccoon. To the westward of the Middle Raccoon, the Drift is overlaid by the Bluff Deposit, and only makes its appearance in the sides of the valleys, where it sometimes attains the thickness of sixty to one hundred feet. The coarse materials of the Drift are largely composed of gneiss and granitic boulders and pebbles, with red quartzite and Lower Silurian limestone boulders. In the valley of Spring creek, a large mass of quartzite was found, one side of which was studded with quartz pebbles, in every respect resembling the conglomerate layers interbedded with the Huronian quartzite formation of Minnesota and northwestern Iowa.

The valleys of the Middle and South Raccoon rivers present some fine examples of terrace formations. But as we ascend the latter stream and the Brushy Fork into the region of the Bluff, the formations are only obscurely defined or wholly obliterated. The following diagrams will convey a more definite idea of the physical conformation of the valleys in the region bordering upon the line of demarkation between the Bluff and Drift Deposits.

FIG. 69.



Fig. 69 represents a profile of the valley of the Middle Raccoon in the vicinity of the confluence of Willow creek. The middle elevation shows the drift ridge on the north side of the valley, and upon the right, the bluff-capped divide between this stream and the Brushy Fork, one hundred and forty to one hundred and sixty feet above the river. The valley is beautifully terraced, the elevation of the highest bench being twenty to thirty feet above the stream.

FIG. 70.

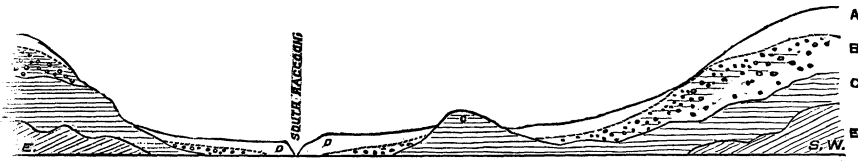


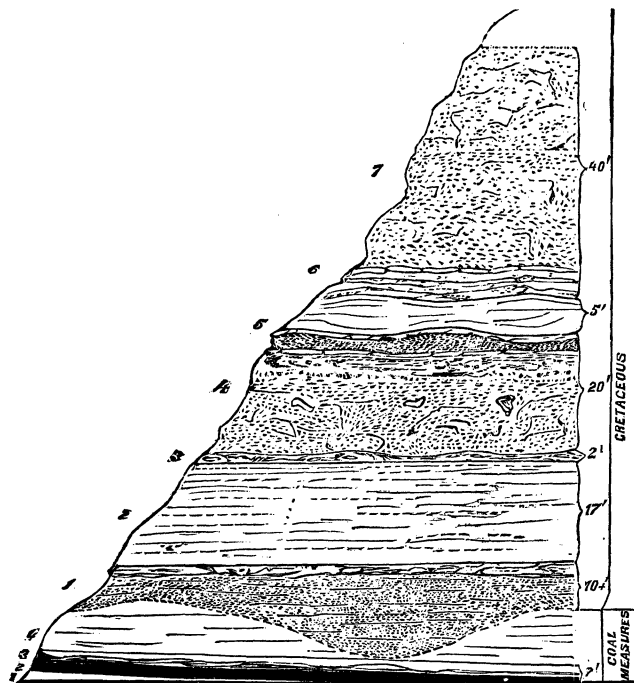
Fig. 70 is a profile of the South Raccoon valley in the vicinity of Guthrie Centre. The uplands rapidly descend to the sloping bottoms bordering the stream. (e) Coal-measure strata; (c) ferruginous grits of the cretaceous, exposed in the valley-sides and in an outlier rising from the bottom plain; (b) drift, which makes its appearance in the slopes. In the valley, there is only the faintest semblance to terrace formation, the bottoms being composed of the finer materials of the Drift and the Bluff Deposits, *d, d*; *a, a*, bluff formation, capping the divides.

Cretaceous. In the southwestern half of the county, numerous exposures of sands, ferruginous grits, and conglomerates and clays, occur in the valleys of the streams, which Dr. White refers to the Nishnabotany sandstone formation of the Lower Cretaceous period. The greatest thickness of these beds, observed at any one locality, is exposed on the Middle Raccoon, in section 33, township 81, range 32. The formation thence spreads westward over the central and western portion of the State. So far as known, only one or two exposures of Cretaceous rocks occur on the east side of the river in the county, and these are seen in the hill-side between Clearwater's and Clark's, in township 81,

ranges 31, 32. They rest unconformably upon the Lower and Middle coal-formations, as they are also known to overlie the Upper coal-formation unconformably in the counties upon the Missouri slope.

One of the finest exposures of Lower Cretaceous strata in the State may be seen in the bluff on the right bank of the Middle Raccoon, in section 24, township 81, range 33, where a vertical thickness of nearly one hundred feet presents the following section :

FIG. 71.



1 2 3 4. At the base of the section, coal and shales of the Lower coal-measures, appearing in the river bank but a short distance below the bluff exposure, at Brushey's coal mine.

No. 1. Light-colored, incoherent sands, capped by a layer of deep-red, shaly, ferruginous sandstone, 10 to 15 feet. This layer rests unconformably upon the coal-measure deposits, 1 2 3 4.

No. 2. Blue, arenaceous clays, 17 feet.

No. 3. Ferruginous, arenaceous layer, containing isolated "pockets" of coal, 2 feet.

No. 5. Soft, red and yellow sandrock, with ferruginous nodules and bands, and thin irregular layers of pebbles, with pebbles of silicified corals of Devonian or Silurian origin, 20 feet.

No. 5. Blue clays, 5 feet.

No. 6. Yellow clay, enclosing ferruginous, arenaceous bands, 4 feet.

No. 7. Very soft, light-colored, irregularly laminated sandstone, 35 to 40 feet.

The gravel and pebbles of No. 4, are quartzose, with few exceptions. No fossils were observed other than the coral-pebbles mentioned above, though the lithological resemblance of these strata to well authenticated Lower Cretaceous Deposits to the westward, seems to preclude the shadow of a doubt respecting their identity. The strata are apparently quite horizontal. The thin band, enclosing the irregular deposits of coal, No. 3, bears a remarkably close resemblance to a similar carbonaceous band in the Cretaceous Deposits of Woodbury county in the northwest part of the State.

Four miles below, and due east of the last mentioned locality, in the northwest quarter of section 26, township 81, range 32, the bluff on the south side of the river, exhibits a vertical section of some ninety feet, consisting of soft, friable sandstones and clays identical with the beds last described. About fifty feet above the water-level occurs a band of ferruginous sandy clays, about two feet in thickness, containing irregular deposits of carbonaceous matter, sometimes in seams, but more frequently in isolated "pockets," which is doubtless the same as No. 3 of the foregoing section. The level occupied by this bed above the river, at the two respective localities, furnishes still additional evidence of the horizontality of these strata—the fall in the stream between the two points being about equal to their difference in elevation at either locality. Also, on the north side of the valley in this vicinity, there are occasional outliers of ferruginous sandstones belonging to the same set of beds, and beneath which in the river banks limited exposures of unequivocal coal-measure strata occur. On Brushy Fork, similar cretaceous exposures are found, though at rarer intervals, and

on the South Raccoon and its tributaries to the south and westward, some of the most interesting, if not as extensive, exposures of these rocks are met with.

In the vicinity of Guthrie Centre, a low outlier of Cretaceous sands and ferruginous grits, with obliquely laminated layers, rises from the bottoms on the east side of the South Raccoon, to an elevation of thirty to forty feet above the stream; and in the slope on the opposite side of the valley, similar beds are seen at about the same level. Above Guthrie Centre, ferruginous gravel deposits appear in the hill-sides, and form low, spur-like ridges, extending out into the valley. Seven miles northwestward from Guthrie Centre, in section 18, township 80, range 32, on lands owned by Mr. Newton, some fifteen feet of brown, friable sandstone accompanied above and below by thin layers of highly ferruginous grits, and underlaid by four feet of blue clays, outcrops in a low bluff on the left bank of the river. A band of brown hematite ore is said to occur at this locality, overlying the beds just mentioned; but its outcrop could not be found, nor were we so fortunate as to procure specimens of the ore for the chemist's examination.

The lowest point on the South Raccoon where exposures of the Cretaceous are known to occur, is a short distance above Dale City. In the declivities which bound the east side of the valley in the southwest corner of township 79, range 30, at an elevation of about ninety feet above the river, a thickness of ten to fifteen feet of coarse conglomerate shows itself, the nearly horizontal outcrop of which may be readily traced for the distance of a mile by the sharply defined contour line it forms in this part of the declivity. The conglomerate is largely composed of quartz pebbles—and even crystals of quartz, where angles are in many instances but slightly abraded, are found embedded in the mass—and quite durably cemented by a ferruginous cementing material. There are sometimes intercalated layers of highly ferruginous grits and ochreous nodules associated with the conglomerate at this locality. Above the outcrop of this bed, the upland

slopes are very gentle, and the surface is strewn with boulders and gravel of the Drift. This is also the most eastern outcrop of the Cretaceous at present known in the State.

In the valley of Beaver creek, in the northern part of township 78, and southern portion of 79, range 31, exposures of conglomerates and sandstones, in all respects identical with those already mentioned, are found. The conglomerate is apparently the highest bed of the Cretaceous in this region. At a locality on Spring branch, known as the "Buzzards' roost," in section 16, township 78, range 31, the conglomerate appears in the hill-side, forming picturesque escarpments several feet in height. Opposite Mr. Thos. Coleman's, on Beaver creek, in section 5, a thickness of fifteen feet of light-colored, incoherent sand, underlaid by five feet or more of beautifully stratified pebble and sandy layers alternating, rise from the water's edge in a low bluff on the south side of the stream. These beds are overlaid by five to ten feet of yellow and bluish clays, interbedded with ferruginous bands and capped by a shaly sandstone. The latter beds are seen in a ravine a few yards south of the bluff exposure. The gravel bed at the base of the section contains water-worn pebbles of silicified corals, probably of Devonian or Silurian age, among which *Favosites* and Cyathophylloid forms were recognized. A short distance lower down the stream, the same beds are again met with in the sides of a ravine, but the lower gravel bed here assumes the character of a rather firmly cemented conglomerate. But a few yards above this exposure, in the same ravine, unequivocal Middle coal-measure beds occur, presenting a few feet in thickness of the horizons between the upper and middle divisions of that formation. The sandstone which separates the two divisions,—bed No. 35 of the general section of Middle coal-measures—affords *Calamites*; and the limestone band overlying the lower carbonaceous horizon of the upper division contains the organisms usually associated in this bed. Beneath the sandstone the Marshall coal has also been opened. We have at this locality the most conclusive evidence showing

the unconformability of the friable sandrock and conglomerate of the Cretaceous and the unmistakable Middle coal-measure strata to one another.

Near Mr. Floring Mann's, about two miles east of the last described locality, in section 36, township 79, range 31, a shaly sandstone, containing impressions of linear leaves, outcrops at an elevation of about seventy-five feet above the Beaver, in the declivity upon the north side of the valley. The sandstone ledge forms an almost uninterrupted, though obscure outcrop for a considerable distance, being underlaid by bluish and buff shaly limestone, which, however, is not seen *in situ*, but fragments of the rock pretty abundantly cover the talus below the sandstone ledge. The relation of the limestone to the sandstone is undetermined; but that the latter is the same as the bed seen in the brow of the bluffs above Dale City there can hardly be a doubt.

During the season of 1867, some exposures were examined on Bear creek, in section 29, township 79, range 32, presenting a limited outcrop showing some five feet in thickness of blue, ferruginous clays, inclosing a thin carbonaceous seam, overlaid by eight feet of coarse, laminated sand-rock, all of which is probably referable to the Cretaceous. It was said that a considerable bed of coal had been opened at this locality, all trace of which, however, was lost, save the half-inch seam mentioned above, and which may prove to be the equivalent of the carbonaceous deposit seen in the exposures on the Middle Raccoon at the first mentioned localities under this head.

Coal-Measures. This group of strata doubtless underlies the entire area of Guthrie county, although in the western portion of the county it is hidden from view by the unconformably superimposed Cretaceous and Post-tertiary deposits. Of the three formations of which the coal-measures are composed, the Middle one occupies the largest surface area, and is here fully developed. These strata have little regularity of dip, owing to the presence of several more or less parallel undulations whose axes, though more or less

subject to variations, seem to have a general north-southerly direction, as observed in connection with the same formations in Dallas county, and to the southward.

The Lower Coal-Formation appears at the surface only in the northeastern part of the county. Above Panora, in the valley of the Middle Raccoon, there are limited exposures of these strata, including one or two comparatively thin beds of coal, which are being worked at three or four points. The highest exposure of coal on the Middle Raccoon occurs in the northwest quarter of section 24, township 81, range 33, in the right bank of the river, at Brushy's coal-bank, where the following section was observed, and which is partially exhibited in the section of the cretaceous exposure given on a previous page.

Section at Brushy's Coal-mine.

No. 4. Light blue clays, exposed 5 to 10 feet.

No. 3. Gray, blue, and black shales, 2 feet. Lower layer contains *Productus muricatus*, *Hemipronites crassus* (?).

No. 2. Coal, 1½ feet.

No. 1. Blue clays, 2 feet exposed above water level.

The coal was covered by the floods at the time the locality was visited, and the bed can be wrought only during the dry season. Judging from the refuse thrown out of the excavation, the coal seems to be highly charged with *pyrite* and other impurities.

Two miles southeast of Brushy's mine, in the southwest quarter of section 28, township 81, range 32, at Mount's Coal-mine, the following strata were observed:

Section at Mount's Coal-mine.

No. 6. Incoherent reddish sands, 10 feet exposed.

No. 5. Yellow shales, with clay nodules, containing plant remains.

No. 4. Blue shales, 3 feet.

No. 3. Black and gray, slightly calcareous carbonaceous shales, 1 foot. Contains *Productus muricatus*, *Hemipronites crassus*, (?), *Lingula carbonaria* (?).

No. 2. Coal, with thin seams of clay, 12 to 18 inches.

No. 1. Blue shales, with imperfect vegetable impressions, *Neuropteris*, &c., 2 feet exposed.

The coal at this locality is about twenty feet above the level of the river. It is, without a doubt, the same bed as that seen at Brushy's mine, although it here occupies a little higher level than at that locality. The coal is of fair average quality, and can be easily mined for a thin bed. Bed No. 6 is believed to represent the base of the Cretaceous deposits; at all events, it bears a closer resemblance to the incoherent sandstone at the base of the section above Brushy's mine than to any of the arenaceous deposits of the Coal-measures.

In the northeast quarter of section 19, township 81, range 32, the same bed has been opened in the right bank of the river at Garne's mine, four or five feet above the water level. It is said to be fourteen inches in thickness, and is overlaid by black shales and blue clays. Also, on Spring Run, a similar thin seam of coal is said to occur, on lands belonging to Mr. John Clark, northeast quarter of section 24, township 80, range 31), where the bed is overlaid by black shales and an exposed thickness of ten feet of soft friable sandrock. The coal at this locality was also concealed by the falling in of the sandstone; it is doubtless the same bed as that described above. The black shales thrown out of the excavation afforded a solitary specimen of *Petrodus*, the only fossil observed here. The sandstone above the coal possibly belongs to the cretaceous,

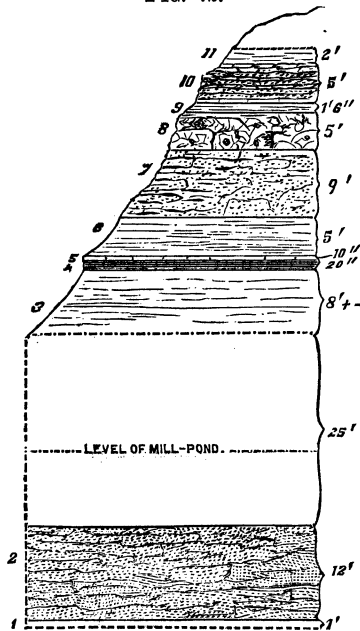
About three miles below Clark's coal-bank, and seven miles above Panora, in the right bank of the river, at Leidick's mine, a thirty-inch coal-bed is said to occur. The entrance of the mine was filled with rubbish, precluding any actual measurements or examinations of the quality of the coal. The bed is overlaid by five to seven feet, or more, of black, pyritiferous shales and blue clays, without fossils. The exact stratigraphical position of this coal-bed remains in doubt, though it is probably the representative of one of the upper beds of the Lower coal-measures, and is so far as known the lowest exposure of the Lower coal-measure coals on the Middle Raccoon in this county.

Middle Coal-Formation. The outcrop of this formation

embraces an area about equal to three townships, in the southeastern portion of the county. On the Middle and South Raccoon rivers, where it presents its most characteristic features and finest exposures, it may be studied to great advantage. To the westward before reaching the middle of the county, the formation disappears from sight, being overlaid in that quarter by the unconformable cretaceous and Post-tertiary deposits which constitute the great bulk of the watershed along this portion of its course.

In the vicinity of Panora mills on the Middle Raccoon, section 31, township 80, range 30, several interesting exposures of Middle coal strata occur, including the horizon of the lower persistent coal of the formation, which we have designated as the Panora coal, for the locality where its peculiarities may be best studied, and which is represented by a two inch seam in the exposure just above the mills. Messrs. Nichols and Hanyan, the proprietors of this valuable water-power, begun a shaft excavation in the bed of the river just below their mills, which affords very satisfactory data for comparison with the same strata at other localities. The following section represents the beds seen in the several exposures in the vicinity of the mills and their relations to one another:

FIG. 72.



Section at Panora Mills.

No. 11. Blue clays, exposed 2 feet.

No. 10. Earthy, fragmentary rock, with arenaceous, shaly partings, about 5 feet.

No. 9. Irregular layers of blue clay, with obscured plant remains, 18 inches.

No. 8. Very compact, heavy-bedded, brecciated rock, with charcoal particles and *Productus muricatus*, 4 to 5 feet.

No. 7. Rather regularly, thin-bedded sandstone, with thin, interrupted coaly partings, 8 to 9 feet. Some times irregularly bedded, soft sandstone.

No. 6. Blue clays, about 5 feet.

No. 5. Earthy limestone band, 8 to 10 inches.

No. 4. Black, carbonaceous shales, with a two-inch seam of coal at the bottom, 20 inches.

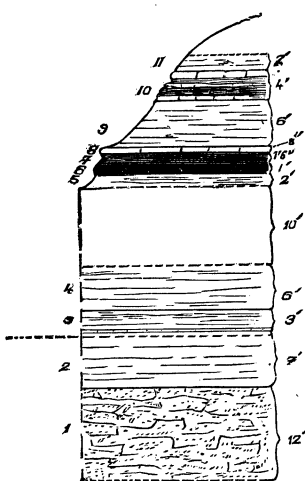
No. 3. Red and yellow shales, 8 feet or more.

No. 2. Unexposed, about 25 feet.

No. 1. Bluish, irregularly, shaly, micaceous sandstone, 12 feet. This bed was passed through in digging the shaft in the bed of the river, and is underlaid by light-colored shales.

It is apparent from a careful examination of the different exposures at this locality, that some of the beds which are usually associated with the Panora coal are wanting here, and their place supplied by other deposits. Thus, the argillaceous, fossiliferous limestone layers commonly found overlying this coal horizon are wholly absent, and their place occupied by the arenaceous deposit, with but a few feet of clays intervening. But the most interesting feature of the exposures at this locality is the remarkable development or introduction of areno-calcareous beds between the lower and middle divisions of the formation, of which a fine example is seen in the bluffs opposite the mills, where these beds afford a very durable building stone. A gentle westerly

FIG. 73.



inclination of the strata is indicated by the apparent high level occupied by the outcrop of equivalent layers on the east side of the river.

About a mile below the above locality, in the vicinity of the woolen factory, the same coal-bed crops out in the bluffs on lands owned by Mr. Wasson—northwest quarter of section 5, township 79, range 30. A shaft begun at a lower level in the bottoms discloses several feet thickness of strata beneath the Panora coal, and furnishes very satisfactory

facilities for identifying the beds here with the exposures found at Panora mills, as shown in the preceding section:

Section at Wasson's Coal-mine, near Panora Woolen Factory.

- No. 11. Blue and reddish clays, exposed 2 feet.
- No. 10. Impure limestone, in three thin layers, with shaly partings, 4 feet. The lower layer is fragmentary, and contains *Productus muricatus*, etc. The middle layer is a more compact buff-rock, with great numbers of *Martinia planoconvexa*, also, *Athyris subtilita*, *Hemipronites crassus*. The upper layer is a gray, tough, even bedded limestone, 8 inches thick, with a minute Gasteropod and comminuted organic remains.
- No. 9. Dark blue clays, about 6 feet.
- No. 8. Bluish, compact, impure limerock, 8 inches. *Discina Missouriensis*, *Productus muricatus*, *Hemipronites crassus* (?) *Athyris subtilita*, *Martinia planoconvexa*.
- No. 7. Black, carbonaceous shales, 18 inches. Contains *Petrodus*, and minute Ganoid scales.
- No. 6. Panora coal, 1 foot.
- No. 5. Blue shales, with imperfect remains of plants in upper part, 10 to 12 feet.
- No. 4. Variegated yellow and red shales, 6 feet.
- No. 3. Bluish shales, with thin indurated band at the base, 2 to 3 feet. In the lower part of the bed great numbers of a small Aviculoid shell occur, besides *Productus muricatus*, *Hemipronites crassus*.
- No. 2. Reddish and blue clays, 7 feet.
- No. 1. Bluish, micaceous sandstone, exposed 12 feet in bottom of shaft.

The shaft-section includes all the beds from one to six. Number one is, doubtless, the same as the corresponding number of the following section. Beneath the sandstone, the horizon of the Lacona coal would be reached, probably, at a depth of ten to twenty feet; but since the continuity of this bed is known to be interrupted, so that it has the character of a local deposit, we cannot, with certainty, say whether the coal will be found at this locality or not. The Panora coal, although a thin bed, has been mined to a considerable extent, and, as usual, the product is of superior quality.

A quarter of a mile east of Wasson's mine, the Panora coal is entirely lost, although the black shales and nodular limestone cap-rock outcrop on nearly the same level as at the

mine. In the opposite hill-side, bordering the outlet of a small ravine, little more than one hundred yards south, a considerable exposure of arenaceous and calcareo-arenaceous deposits is found, which bear an unmistakable resemblance to the upper beds seen in the exposures at Panora mills. It would appear that there is either a considerable dip of the beds to the southward in order to carry the horizon of the Panora coal beneath the lowest bed seen in the exposure on the south side of the ravine, or the total replacement of this coal and its accompanying overlying beds, as observed at Wasson's mine, by the local development of arenaceous material. The upper or calcareo-arenaceous bed seen in the ravine affords a few fossils, among which were recognized, *Productus muricatus*, *P. æquicostatus*, *Chonetes mesoloba*, *Hemipronites*, *Petrodus*. There is also a similar and probably identical stratum on Mosquito creek, Dallas county, which outcrops in the hill-side above Parker's coal-bank, though evidently at a much greater height above the Panora coal than at the localities last described.

In the vicinity of Brumbaugh's mill, one and a half miles southward of Panora, northeast quarter of section 9, township 79, range 30, the Panora coal again outcrops in the bluffs on the left bank of the river, where the following section was obtained:

Section at Brumbaugh's mill.

No. 6. Two or three thin bands of impure limestone, with shaly partings, about 3 feet. The lower layer contains *Productus muricatus* abundant, *Athyris subtilita*, *Chonetes mesoloba*, *Hemipronites crassus* (?), and in the middle layer the little *Martinia planoconvexa* occurs in great abundance.

No. 5. Dark blue shales, 7 to 9 feet.

No. 4. Rather hard, brittle, bluish impure limestone, weathers brown, 6 to 8 inches. Forms a substantial roof to the entries, and contains the following fossils: *Productus muricatus*, *Chonetes mesoloba*, *Athyris subtilita*, *Martinia planoconvexa*, *Rhynchonella Uta*, *Pernopecten* (?), sp. undet., *Euomphalus*, &c.

No. 3. Black carbonaceous shales, sometimes calcareous, 18 inches. The following species occur in this bed at this locality: *Productus muricatus*, *Chonetes mesoloba*, *Athyris subtilita*, *Martinia planoconvexa*, *Spiriferina Kentuckensis*, *Rhynchonella Uta*, *Discina Missouriensis*, *Aviculopecten rectilateraria*, *Pleurophorus* (?), sp. undet., *Petrodus*, and minute scales of Ganoids.

No. 2. Panora coal, 1 foot.

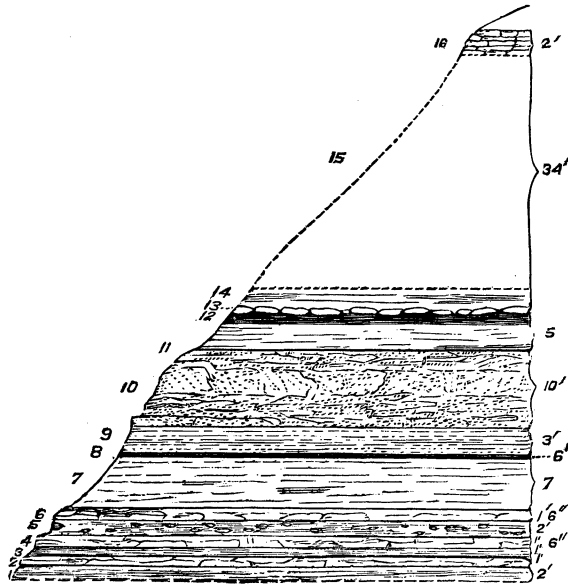
No. 1. Variegated bluish, reddish, and yellow shales, with concretionary band at the base of the exposure, 14 feet. In the upper portion of the bed the imperfectly preserved remains of plants are found.

The strata at this locality have a very decided inclination to the southeastward. The coal-bed has been opened at several places, and exhibits a thickness of 12 to 14 inches of excellent coal. The principal mines are Knowlton's, Frazier's, and Wilson's. At the latter bank the entry has reached the distance of seventy-five yards from the entrance, the firmness of the limestone cap-rock greatly facilitating the economical working of the coal. The local demand for coal is principally supplied from these mines and that at Wasson's, near Panora. The fossiliferous layers of impure limestone are but imperfectly exposed here, although they present the same appearance as at Wasson's coal-bank and numerous other localities throughout the Middle coal region. About forty-five feet above the Panora coal, a soft reddish sandstone appears in the hill-side, which belongs to some of the arenaceous beds in the middle division of this formation.

The next exposures encountered on descending the Middle Raccoon, occur in the neighborhood of Fisk's mills, about six miles southeast of Panora. The middle division of the formation is here beautifully displayed, presenting its most persistent and characteristic peculiarities. The general inclination of these strata is to the southeastward, although it is quite irregular, owing in a great measure, doubtless, to the local thickening and thinning of certain beds. Immediately at the mills, the upper portion of the middle division, including the Marshall coal, overlaid by about forty feet of the upper division, presents the following section:

FIG. 74

Section at Fisk's mills, on Middle Raccoon.



No. 16. High in the slope, 90 to 100 feet above the river, an imperfect exposure of thin bedded buff limestone, 2 feet thick, is seen, containing comminuted organic remains, with the following recognizable species: *Productus æquicostatus*, *Chonetes mucronata*, *Athyris subtilita*.

No. 15. Unexposed; about 32 feet, probably made up of shales.

No. 14. Blue shales, with *Cyathaxonia*, (sp. undet.), crinoidal remains, *Productus punctatus*, *P. longispinus*, *Chonetes mucronata*, *Hemipronites crassus* (?), *Spiriferina Kentuckensis*, *Martinia planoconvexa*, *Athyris subtilita*, *Retzia punctilifera*, two species of *Lamellibranchiata*, *Pleurotamaria*, *Bellerophon carbonaria*, etc.

No. 13. Compact, nodular, blue, impure limestone, 4 to 6 inches.

No. 12. Carbonaceous shales, 1 foot.—Lower carbonaceous horizon of the the upper division.

No. 11. Light colored clays, about 4 feet.

No. 10. Grayish and red sandstone, with shaly arenaceous layers, about 10 feet. Very obscure plant remains, *Neuropteris*, etc.

No. 9. Blue and yellow arenaceous shales, 3 to 4 feet.

No. 8. Marshall coal, highly bituminous shale or impure coal 6 inches.

No. 7. Dark blue and light colored shales, 5 to 7 feet.

No. 6. Thin, irregularly bedded impure limestone, 1 foot.

No. 5. Blue shales, with nodules, 2 feet.

No. 4. Very irregularly bedded, earthy limestone, 18 inches. *Productus*

muricatus, *P. æquicostatus*, *Hemipronites crassus* (?), *Athyris subtilita*, *Martinia planoconvexa*, *Rynchonella Uta*, crinoidal remains.

No. 3. Blue shales, 1 foot.

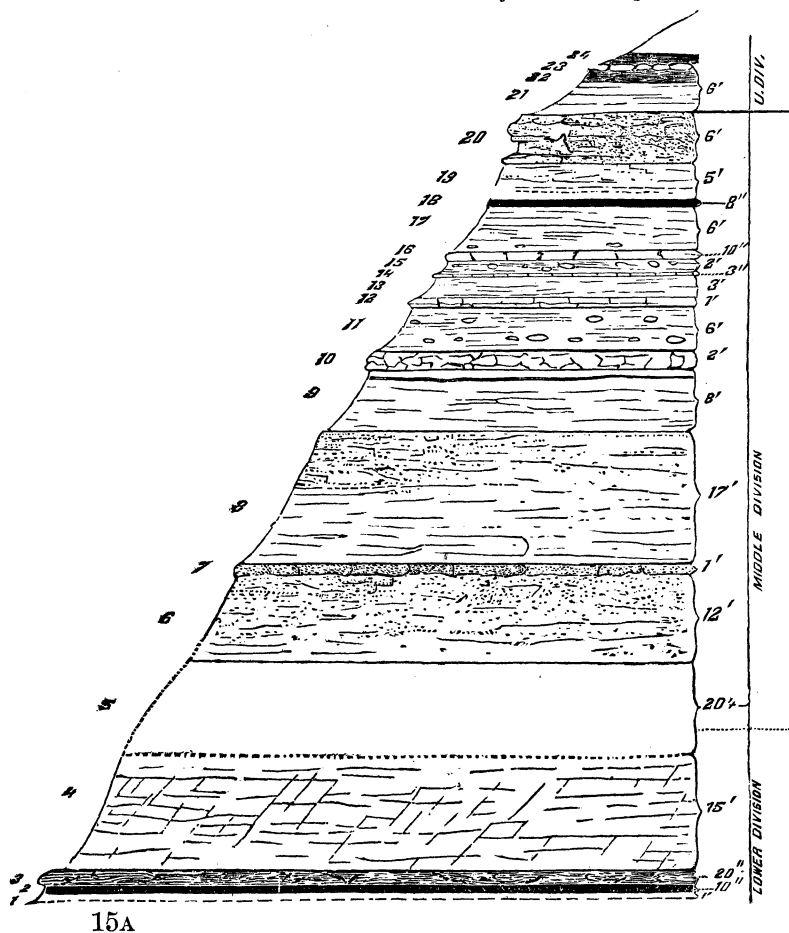
No. 2. Impure limestone, 1 foot. Contains *Productus æquicostatus* in great abundance, besides *P. muricatus*, *Chonetes mesolobus*.

No. 1. Blue and gray shales, exposed 2 feet, at an elevation of 24 feet above the level of the mill-pond.

The Marshall coal outcrops at an elevation of forty feet above the mill-pond, and is represented by a thin seam of rotten coal. The lower carbonaceous horizon, Nos. 11 to 14,

FIG. 75.

Section on Hook's branch and at head of Fisk's mill-pond.



inclusive, and the limestone bed No. 16, are all that is seen of the upper division. The Lonsdale coal, which appears high in the bluffs a mile below at Duck's mill, Dallas county, has been denuded at this locality. The lower calcareous layers are not durable enough for building purposes, nor sufficiently pure for making quicklime; the shelly limestone high in the slope may be of sufficient thickness to be quarried for the ordinary uses. The sandstone, No. 10, is too friable to answer for building purposes.

Three quarters of a mile north of the mills, on Hook's branch, the same beds are exposed at frequent intervals, from the lower carbonaceous horizon of the upper division, which is only seen in the bed of the ravine high up its course where it enters the prairie, downwards to the arenaceous beds in the middle portion of the middle division, representing a vertical thickness of about sixty feet of the latter division, as shown in the following section, which exhibits the order of superposition of all the strata exposed at this locality, including the Lacona coal of the lower division, as it is seen in the margin of the river, half a mile or so above the mouth of Hook's branch:

- No. 24. Trace of yellow shales.
- No. 23. Blue, nodular, impure limestone, 6 to 15 inches. With *Polyzoa*, *Martinia planoconvexa*, *Chonetes mesoloba*, unusually diminutive, *Athyris subtilita*.
- No. 22. Black carbonaceous shales, 1 foot. *Discina* ———.
- No. 21. Yellow shales, 3 to 6 feet.
- No. 20. Gray, more or less shaly sandstone, 4 to 6 feet.
- No. 19. Yellowish blue, laminated arenaceous shales, 5 feet.
- No. 18. Marshall coal, 8 inches.
- No. 17. Yellow and blue shales, with nodules at base, and near top obscure vegetable remains, 6 feet.
- No. 16. Irregularly bedded impure limestone, 10 inches.
- No. 15. Yellow clays, with nodules, about 2 feet.
- No. 14. Thin argillo-calcareous band, 3 inches; sometimes represented by calcareous shales, crowded with *Productus muricatus*, besides *P. æquicostatus*, *Chonetes mesoloba*, *Hemipronites crassus*, *Athyris subtilita*.
- No. 13. Yellow and blue clays, about 3 feet.
- No. 12. Light gray, rather compact earthy limestone, 1 foot. *Productus æquicostatus* abundant, *P. muricatus*, spines of Echinoids.

No. 11. Red, blue, and yellowish shales, with nodular bands, 6 feet. *Productus muricatus*, *P. æquicostatus*, *Athyris subtilita*.

No. 10. Fragmentary or shaly impure limestone, 2 feet.

No. 9. Blue and reddish clays, 8 feet. Near the top, band of fossiliferous shale, with *Martinia planoconvexa* and *Petrodus*.

No. 8. Blue and reddish clays, passing upwards into yellow arenaceous shales, and sometimes shaly sandstone near the top, 17 feet.

No. 7. Rather compact, shaly, gray sandstone, 1 foot. With *Productus æquicostatus*, *Hemipronites crassus*, (?), *Myalina* (sp. undet.)

No. 6. Yellowish and blue gritty clays, sometimes the upper part presents the appearance of a soft, gray arenaceous shale, 12 to 15 feet.

No. 5. Unexposed, 15 to 25 feet. Probably includes the horizon of the Panora coal.

No. 4. More or less indurated blue shales, exposed 15 feet.

No. 3. Dark gray, more or less calcareous bituminous shales, forming a heavy sheet resting immediately upon the coal, 20 inches. This bed is abundantly stored with fossil remains, of which the following forms have been identified: *Productus muricatus*, very abundant, *Hemipronites crassus* (?), *Athyris subtilita*, and a minute Gasteropod.

No. 2. Lacona coal, 6 to 10 inches.

No. 1. Blue shales, exposed to level of river at the head of the mill-pond, 1 foot.

Half a mile southwesterly of the principal exposures on Hook's branch, in a high bluff bordering the north bank of the river, the same beds described above are again met with, presenting, however, a somewhat marked contrast in the stratigraphical details of the section. At an elevation of ninety feet above the river, the lower carbonaceous horizon of the upper division crops out, overlaid by its cap-rock of impure limestone, which is here fifteen inches in thickness. The sandstone, No. 20, is exposed two to three feet, below which the slope is too imperfectly exposed to show the Marshall coal, (No. 18), nor more than a trace of the fossiliferous calcareous layers, Nos. 12 to 16, inclusive. The soft sandy shales at the top of No. 8, are replaced by yellow gritty clays, and the sandstone, No. 7, which on Hook's branch, form a bed of five or six feet in thickness, is represented by a thin band of compact, gray sandstone, containing the same organisms—*Productus æquicostatus*, *Hemipronites*, *Myalina*, and very imperfect fish remains, probably the teeth

of some Hybodont shark. The remaining lower beds are represented in the foregoing section. All the strata which have been identified with their equivalents on Hook's branch, occupy a slightly higher position than they do at that locality. The westerly uprising of the strata brings to view at the head of the mill-pond, four or five hundred yards above the bluff outcrop, the Lacona coal, which appears in the right margin of the stream, just above low water, as shown in the foregoing section, Nos. 1 to 4. A few yards below this last exposure, we find fragments of the fossiliferous limestone layers which overlie the Panora coal, thus indicating the presence of that coal at this locality also, although its outcrop is hidden from view by the accumulation of detrital material along the base of the bluffs. The lower or Lacona coal has been drifted into at this place, and in a ravine a short distance from the river bank outcrop, the bed is reported to be eighteen to twenty inches thick. On Hook's branch, the Marshall coal, although a thin bed, is of excellent quality, and has been wrought by stripping off the overlying shales wherever its outcrop favored this mode of working the bed.

A comparison of the foregoing section, with that observed above the mouth of Mosquito creek four miles below in an east-southeast direction, exhibits a remarkable diminution in the thickness of the strata intervening between the Panora and Marshall coal horizons, being hardly half the thickness attained by these members at the locality between Mosquito creek and the eastern border of Guthrie county, mentioned under the head of this formation in the description of Dallas county. It will be further observed that the arenaceous and argillaceous deposits in the lower portion of the middle division of the formation, present the greatest contrast in relative development, while the upper portions of the sections are about the same at both localities.

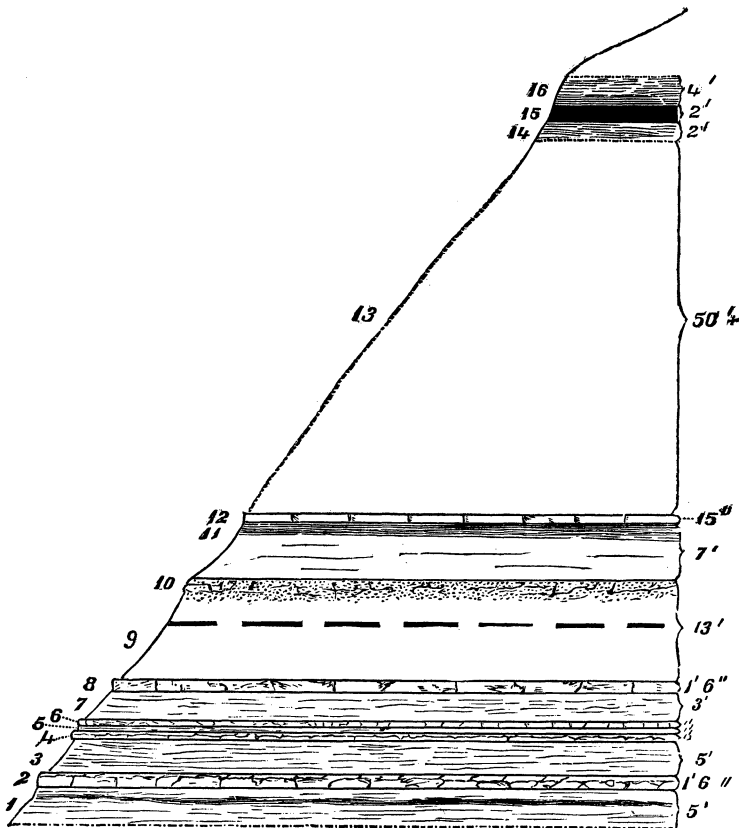
In the northeast corner of township 78, range 30, about three miles southeast of Fisk's mills, the Lonsdale coal has been opened in a ravine on the south side of Huggin's

branch, at an elevation between eighty and ninety feet above the Middle Raccoon. The coal is two feet thick, and separated in two equal layers by a thin seam of light-colored clay. The bed rests upon light ash-colored clays, and is overlaid by four feet of slightly calcareous, bituminous shales, presenting the varied fauna that particularly distinguishes this horizon from its associates. The coal is of very good quality, and is obtained by stripping off the superincumbent earth.

Half a mile east of Huggin's coal mine, in section 1, township 78, range 30, the strata associated with the horizon of the

FIG. 76.

Section on Huggin's Branch.



Marshall coal are exposed in the south side of the branch, presenting the section given below, showing approximately the relative position of the Lonsdale coal to these exposures:

No. 16. Black and dark-gray shale, with indurated, calcareous bands, passing into light-colored clays above; 3 to 4 feet exposed. The following are among the species of fossils most abundant in this bed: Crinoidal remains, *Athyris subtilita*, *Hemipronites crassus*, (?), *Chonetes mesoloba*, *Productus æquicostatus*, *Edmondia*, (?), *Leda bellastrata*, *Nucula*, *Gervillia*, and other *Lamellibranchiata*; *Pleurotomaria*, two species; *Bellerophon*, three species; *Orthoceras*, *Nautilus occidentalis*, etc.

No. 15. Lonsdale coal, 2 feet.

No. 14. Ash-colored clays, exposed 2 feet.

No. 13. Unexposed, probably 50 feet or more. Below the Lonsdale coal no exposures of the intermediate strata are met with until reaching the horizon of the Marshall coal, as seen at the last mentioned locality. Here the upper portion of the exposure, although the outcrop is obscure, is sufficiently distinct to be unmistakable, presenting the appearance represented as follows:

No. 12. Compact, blue, earthy limestone, 15 inches.

No. 11. Black, carbonaceous shales, underlaid by yellow clays, all 7 feet. Lower carbonaceous horizon of upper division.

No. 10. Gray, shaly sandstone, exposed 2 feet.

No. 9. Unexposed, about 11 feet, including the Marshall coal whose outcrop is concealed by the debris upon the slope.

No. 8. Compact, gray, impure limestone, 18 inches.

No. 7. Blue shales, 3 to 4 feet.

No. 6. Yellow, earthy limestone, decomposed, 1 foot. *Athyris subtilita*.

No. 5. Blue shales, 1 foot.

No. 4. Irregularly bedded, shaly, impure limestone, 1 foot. Lower part contains *Productus æquicostatus*, abundant, and in the upper shaly portion, *Productus muricatus*, *Chonetes mesoloba*, *Hemipronites crassus*, (?) *Athyris*.

No. 3. Blue and ash-colored clays, 5 feet.

No. 2. Heavy-bedded, gray, impure limestone, decomposed above, 2½ feet.

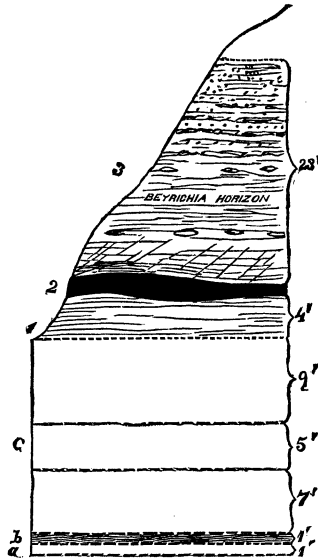
No. 1. Dark-bluish, more or less indurated shales, exposed 5 feet; base about 30 feet above the level of the Middle Raccoon. In the upper part of the bed fucoid-like markings occur, besides *Petrodus* and spines, *Martinia planoconvexa*, *Discina*, etc.

The Marshall coal does not appear here, and the overlying sandstone is evidently much thinner than it is generally found to be. The lower black shale of the upper division, bed No. 11, is about fifteen feet lower than the level occupied by the Lonsdale coal at Huggin's mine. In the mention made of the exposures on the Middle Raccoon, above the

confluence of Mosquito creek, about half a mile east of the present locality, in Dallas county, it was observed that the strata have a gentle westerly inclination. Hence it is reasonably inferred that the beds mentioned in the above section dip sufficiently to receive the proper thickness of strata that are known to occur between this upper coal-bed and lower carbonaceous deposit at the base of this division. The outcrop of the Lonsdale coal at Huggin's is probably in the middle of a shallow northerly and southerly synclinal depression.

In the bed of the South Raccoon at Cave's mill, and in the south side of the valley on Mr. Raber's farm, in the southeast quarter of section 10, township 78, range 30, the fossiliferous, earthy limestone layers pertaining to the middle portion of the middle division, below the position of the Marshall coal, make their appearance, but so attenuated as scarcely to be recognized. At Marshall's coal mine on Long branch, in the northwest quarter of section 24, township 78, range 30, a mile and a half southeastward from Raber's, a bed of very good coal has been opened, presenting a variable thickness of ten to thirty inches. The following section exhibits the character of the strata associated with the coal at this locality:

FIG. 77.



Section at Marshall's Coal-mine.

No. 3. Gray and blue, laminated or indurated clay, passing upwards into arenaceous shales, with irregular ferruginous nodules, and indurated shaly layers, 20 to 22 feet. Vegetable remains and a small *Lingula* occur in the lower part, and in the shaly layers above imperfectly preserved linear leaves. About nine feet above the coal, a band of gray iron stained shales is literally crowded with the minute shells of *Beyrichia*.

No. 2. Marshall coal, 10 to 30 inches.

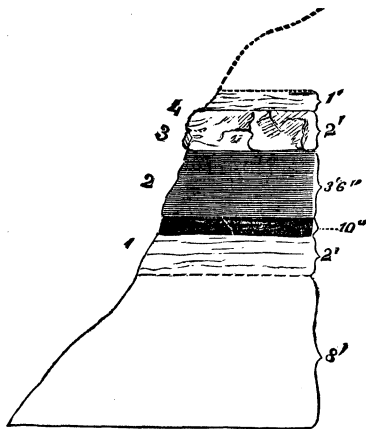
No. 1. Ash-colored clays, exposed to bed of Long branch, 4 feet. A few imperfect remains of plants are found in this bed—*Pectopteris*, *Sphenopteris*, etc.

From the fine development of the coal at this locality, we have applied to the bed the name by which the mines are here known—the Marshall coal. The bed is quite variable in thickness, and is observed to thin rapidly to the southeastward, or in the direction of its local inclination. The *Beyrichia* horizon above the coal corresponds exactly to a thin band containing the exuviae of this minute crustacean, which overlies the Marshall coal in the exposures on Hickory branch, Dallas county. This identification is further sustained by data obtained from a boring which Mr. Marshall caused to be made in the bed of the branch near the mines. About twenty-five feet beneath the coal, a one foot layer of carbonaceous material was passed through, (*b*) which is believed to be the equivalent of the locally developed bituminous shales sometimes found in this position, as observed on Miller's branch near Adel, Dallas county, and other localities, and which is represented by bed No. 29, in the general section of the Middle coal-measures. The over-lying arenaceous deposit (No. 3), is also unusually exaggerated as compared with its normal condition. A fair quality of coal is obtained at this locality, by the ordinary process of drift mining.

In the left bank of the South Raccoon, just below Pearson's mill, in the southwest quarter of section 15, township 78, range 30, a two-foot bed of fragmentary, earthy limestone outcrops, underlaid by dark blue clay, in which occur *Petrodus* and *Martinia planoconvexa*. This is the equivalent of Nos. 1 and 2 of the section on Huggin's branch—bed No. 26, General Section of Middle coal-measures. Also on Mr. John Windermaker's farm, section 11, township 78, range 30, a limited outcrop of impure fossiliferous limestone is found in a ravine on the north side of the valley, which belongs to the calcareous layers above the bed seen at

Pearson's mill, and underlying the Marshall coal. About a mile north of Pearson's mill, a thin seam of coal crops out in the bed of a ravine in the southeast quarter of section 3, township 78, range 30, known as Miller's coal-bank. The bed is equivalent to the lower carbonaceous horizon of the upper division, and in connection with the accompanying strata affords the following section:

FIG. 78.



Section at Miller's Coal-mine.

No. 4. Yellow shales, exposed 1 foot. Contains *Chonetes mesoloba*, *C. mucronata*, *Hemipronites crassus* (?)

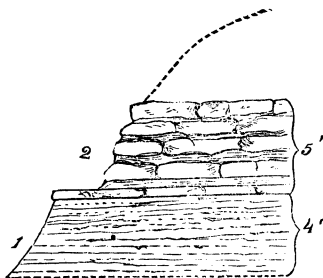
No. 3. Irregularly bedded, bluish gray, earthy limestone, 2 feet. *Productus longispinus*, *Chonetes mesoloba*, *Athyris subtilita*, *Spirifer cameratus*, *Pernopecten*, *Allorisma*, etc.

No. 2. Black, fissile, carbonaceous shale, 3½ feet, with irregular seams of coal at bottom 6 to 10 inches thick. The black shales contain *Petrodus* and spines.

No. 1. Blue shales, exposed 2 feet, and 8 feet above level at Pearson's mill-pond.

The coal is evidently a local deposit, and it is hardly reasonable to expect that it will be found sufficiently thick to be profitably wrought. In the river bank, a few yards west of the coal-bank, the same bed again outcrops, but the coal-seam is here absent, and the cap-rock, bed 3, is changed from its nodular condition at the mine to a heavy bedded layer two feet in thickness. There appears to be a slight local undulation in the strata at this locality independent of the general southerly inclination of the beds; the coal-mine exposure occupying a level about four feet below that

FIG. 79.



in the river bank. The sandstone upon which this division rests is not exposed above the water level. Ascending the ravine in a southerly direction from the coal-mine, near its head, in the northeast quarter of section 10, a ledge of limestone crops out at an elevation of about ninety feet above the coal-bed at Miller's mine, presenting the following section:

No. 2. Thin-bedded, compact, gray limestone, in five layers, separated by marly clay partings, 5 feet. The following fossils were observed in this bed:—*Fusulina cylindrica*, *Zaphrentis*, (?) crinoidal remains, *Chonetes*, two or three species of *Polyzoan*, *Athyris subtilita*, *Spiriferina*, *Kentuckensis*, *Martinia planoconvexa*, *M. lineatus*, *Productus longispinus*, *P. semireticulatus*, *Hemipronites crassus*, (?) *Pleurotomaria*, (?).

No. 1. Blue and yellow, gritty shales, exposed 4 feet.

The limestone, though quite irregularly bedded, is durable and considerably quarried for building purposes and for making lime. There is doubtless a greater thickness of strata intervening between the two exposures just named than would seem to be the case from their relative level; but the beds are known to dip to the south at a comparatively rapid rate, which would be ample to admit the entire thickness of the upper division, and also the lower beds of the Upper coal-measures, between the horizons of the two extreme outcrops. The upper limestone described above is believed to belong to the Upper coal-formation; hence the Lonsdale coal of the Middle coal-measures must occur at a lower level between the quarry and the coal-mine, although up to the present time its existence remains undiscovered.

About two miles in a direct line southwardly from the last mentioned locality, on a small affluent of Deer creek, called Walled branch, we find an exposure of limestone undistinguishable from the bed last described, but occupying a lower level by about sixty feet than at the exposure above Miller's coal-mine. The ledge at this locality is underlaid by yellow, gritty shales, and the same association of fossil-forms prevail

in the limestone as were observed in the equivalent layers shown in the foregoing section. The exposure on Walled branch affords a very good building stone, the rock is firm and in layers from four to ten inches thick.

Half a mile south of Morrisburg, in lot 13, section 4, township 78, range 30, the upper sandstone of the middle division appears in the left bank of the South Raccoon, forming a ledge about eight feet thick at an elevation of twenty feet above the stream. It is overlaid by an imperfect exposure of the carbonaceous shales at the base of the upper division. The accumulation of debris upon the slope below the sandstone, hides from view the outcrop of the Marshall coal which doubtless occurs in place between the sandstone and the water level. Mr. Kinworthy of Dale City, informed us that in sinking a shaft in the bottoms on the south side of the river between a quarter and half a mile southwest of the above exposure, a fourteen-inch bed of coal was found at a depth of twenty feet beneath the surface, which may be equivalent to the Marshall coal, the westerly inclination of the strata being sufficient to account for the apparent lower position of the bed at this point than it holds in the river bluff outcrop a short distance below.

Near the village, at Williams' quarry, in lot 6 of section 4, the upper limestone is again met with, presenting the same appearance as observed on Walled branch and in the ravine above Miller's coal-bank, a mile and a half southeastward. The quarry is about one hundred and thirty feet above the river, or about one hundred feet above the carbonaceous bed in the river bluff exposure before mentioned. It will be seen that the relative position of this bed to the carbonaceous horizon, in the lower part of the upper division, is about the same at both localities; and wherever the limestone may be found, it will afford a reliable guide in determining the character of the strata that occur beneath it. The bed at Williams' quarry, shows the same lithological and palæontological peculiarities with which we have become familiar in the study of this horizon at other localities. The ledge

is made up of five layers, varying from four to twelve inches in thickness, and underlaid by yellow and blue gritty shales. It affords a tolerable building stone, for which purpose it is much used in this vicinity. The Lonsdale coal, which occupies a position beneath the limestone bed, has not been discovered at this locality—the disintegration of the soft shales by which it is accompanied, having effectually concealed its outcrop. But that this coal may be successfully sought in the neighboring ravines there seems to be no reason to doubt.

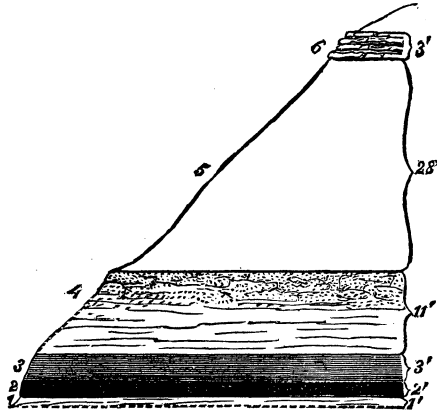
Above Dale City, the coal-measures are wholly lost to view in the valleys of the South Raccoon and Brushy Fork, their place being occupied by, or hidden beneath, the heavy accumulation of detrital materials which were deposited during the early epoch of the Cretaceous period. But, ascending the tributaries south and west of the former stream, in the southern tier of townships, the Middle coal-formation is still the predominant geological feature of the region, and only disappears beneath the superficial deposits on gaining a point well up on the eastern flank of the Great Watershed divide.

From a careful examination of the valley of the South Raccoon, above the confluence of the Middle Raccoon, three distinct undulations in the coal-measure strata have been detected between the latter point and the great divide. The first undulation crosses the valley in the vicinity of Redfield; the second one occurs near Morrisburg, and has, apparently, a more northwesterly and southeasterly trend than the former; and the most westerly one is met with in the immediate region of the watershed in the western portion of the county. West of the Morrisburg fold, the westerly inclination of the strata has carried down the Lonsdale coal to a level much below that which it probably occupies near the latter place, and which also accounts for the occurrence of the Upper coal-limestone, previously mentioned in the valley of Wall branch, so considerably below the position it holds in the uplands in that neighborhood.

In the northeast quarter of section 20, township 78,

range 30, in the valley of Deer creek, at Lonsdale's coal-mine, the above mentioned coal outcrops nearly on the same level as the carbonaceous shales at the base of the upper division in the river bluff below Morrisburg. The exposure at this locality presents the appearance given in the accompanying section:

FIG. 80.



Section at Lonsdale's Coal-mine.

No. 6. Ledge outcrop of compact gray limestone, thin bedded, 3 feet exposed. Contains *Fusulina*, crinoidal remains, *Athyris subtilita*, *Martinia lineatus*.

No. 5. Unexposed, about 25 feet.

No. 4. Light clay passing upwards into soft sandstone, about 11 feet.

No. 3. Dark carbonaceous, slightly calcareous shales, 3 to 4 feet. Contains abundance of fossils—*Productus longispinus*, *Chonetes mesoloba*, *Hemipronites crassus*, *Athyris subtilita*, *Leda bellastrata*, *Nucula*, and other *Lamellibranchiata*, *Macrocheilus*, *Pleurotomaria*, *Bellerophon*, several species, *Orthoceras*, *Nautilus occidentalis*, &c., &c.

No. 3. Lonsdale coal, 20 to 30 inches.

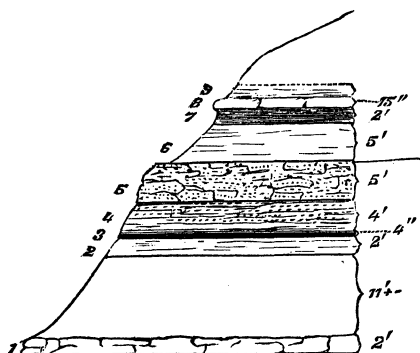
No. 1. Light colored clays, exposed 6 feet to bed of Deer creek.

The shales immediately overlying the coal are profusely stored with organic remains. These are largely represented by diminutive species, and, as a whole, render this horizon one of the most distinctive and interesting in the coal-measures. The limestone seen in the valley-side forty-five to fifty feet above the bed of the stream, may be referable to the limestone horizon found at Williams' quarry, near Morrisburg and elsewhere along the eastern border outcrop of the Upper coal formation. Since this property passed into the hands of Mr. John Lonsdale, of Dale city, the mine has been greatly improved and successfully operated. The coal is of fair average quality, and already large quantities have

been taken out to supply the local demand. A thin seam of coal is said to occur a few feet above the bed that is being wrought, but no trace of its presence could be found at the time of our visit.

In the vicinity of Mr. Floring Mann's, on Spring branch

FIG. 81.



of Beaver creek, (lot 12 of section 3, township 78, range 31), the lower beds of the upper division, and the upper portion of the middle division, including the Marshall coal, are well exhibited, as shown in the following section:

Section on Spring branch.

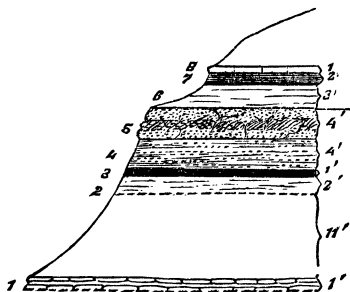
- No. 9. Yellow shales, exposed 2 feet.
- No. 8. Blue, rather compact, earthy limestone, 15 inches. *Martinia planoconvexa*, *Athyris subtilita*, *Productus longispinus*, *P. muricatus*.
- No. 7. Carbonaceous shales, 2 feet.
- No. 6. Yellow clays, about 5 feet.
- No. 5. Light-colored, shaly sandstone, 5 feet, with *Calamites*.
- No. 4. Yellow and blue arenaceous clays, 4 feet.
- No. 3. Marshall coal, 4 inches.
- No. 2. Blue shales, 13 feet.
- No. 1. Fragmentary, buff, impure limestone, 2 feet, exposed in bed of ravine.

The Marshall coal is here a thin seam of rotten coal of no practical value. The position of the above horizon is probably not less than fifty feet above the equivalent strata at Morrisburg, four or five miles due east. In the valley slope on the south side of Beaver creek, a bed of dark gray limestone outcrops, which possibly belongs to the upper division. In the northeast part of section 4, the same strata are known to occur, Mr. Mann having successively encountered the lower carbonaceous shales and the Marshall

coal in sinking a well and boring on his farm. High up Spring branch other limited rock exposures were visited, but they were too obscure to enable their stratigraphical relations to be satisfactorily determined, although they doubtless belong to the upper portion of this formation. Outliers of the Cretaceous conglomerates are frequently met with in this vicinity, filling apparently all the inequalities of surface in the underlying coal-measure strata.

Two miles above Spring branch, the Marshall coal again outcrops in a ravine on the south side of Beaver creek, (lot 4 of section 5, township 78, range 31), at the locality known as Young's coal-bank, where the strata with which it is associated, present much the same lithological aspects as at the locality last mentioned. The annexed section was obtained at this point:

FIG. 82.



Section at Young's Coal-mine, Beaver creek.

- No. 8. Blue, impure limestone, weathers brown, 1 foot. *Martinia planoconvexa*.
- No. 7. Carbonaceous shale, 2 feet. A seam of impure coal, 2 to 4 inches thick, is found at the bottom of the shales. *Petrodus* occurs in the shales.
- No. 6. Blue clays, about 3 feet.
- No. 5. Heavy bedded, red sandstone, with obliquely laminated layers, 4 feet.
- No. 4. Yellow, arenaceous shales, 4 feet, with gray, calcareous layer just above the coal, in which occur *Myalina*, ———, *Hemipronites crassus*, and obscure impressions of ferns and other plants.
- No. 3. Marshall coal, 10 to 14 inches.
- No. 2. Blue and yellow clays, exposed imperfectly, 13 feet. In the upper part, obscure vegetable remains are found.
- No. 1. Yellow, thin bedded, earthy limestone with clay partings, 1 foot. This bed outcrops in the side of the ravine several yards below the coal-mine. It contains a few fossils: *Productus muricatus*, *Athyris subtilita*, etc.

The Marshall coal is here quite irregular, averaging about twelve inches in thickness; it is a handsome, brittle coal, quite free from impurities. An interesting and anomalous

feature is observed at this locality, in connection with the shales overlying the coal which present a well developed local fauna, comprising forms not known in this horizon elsewhere. The exposure is capped by the lower carbonaceous shale of the upper division, which also shews a thin seam of coal at its base, in this respect recalling to mind a similar locally developed coal seam in this horizon at Miller's mine near Pearson's mills.

Upper Coal-Formation. The only exposures of Upper coal strata at present known in the county are those in the vicinity of Morrisburg and on Deer creek, which have been already incidentally mentioned in the foregoing pages. From these data, the formation is apparently confined to a limited area in the southern tier of townships, so that it forms the least considerable member of the rock strata found within the limits of the county.

Economic Geology. Coal is by far the most important mineral product of the county. These deposits are comparatively thin, and belong principally to the Middle coal-formation. However, it is not improbable that, in the northeastern portion of the county where the lower coal series is known to occupy a considerable area immediately underlying the Drift, the thicker coals of the productive measures may be reached by means of shafts at moderate depths below the surface. At the present time, the local demand, is easily supplied by working the thin beds, and at the price coal brings throughout this section, there is hardly any branch of industry more profitable than coal mining. The Middle coal-measures also locally present good workable coal-beds; but it is evident that these cannot be relied upon for persistency, with perhaps the exception of the Lonsdale coal, which has averages about twenty inches in thickness. There seem to be hardly a doubt that this coal may be successfully sought by boring in the greater portion of the two eastern townships of the southern tier, township 78, range 30, 31. To the northward, along the Middle Raccoon, this has doubtless been almost entirely denuded,

with only here and there a limited outlier, as that seen at Duck's mills, on the eastern border of the county.

Iron, in the form of brown hematite ore occurs in limited quantity both in the coal-measures and Cretaceous. In the latter formation this material is largely disseminated through the sand and gravel beds constituting the principal ingredient of the cementing material. It is not infrequently found in a purer condition as nodules in the interstratified arenaceous clays, but the quantity is probably too small ever to become valuable for economic purposes.

Building Materials. The upper limestone bed of the Middle coal-measures affords a tolerable building material, yet the fact cannot escape notice that Guthrie county is meagrely provided with good building stone. These materials for building must eventually be obtained from the adjoining county of Madison, whose Upper coal-measure limestone beds are capable of furnishing inexhaustible supplies of stone and lime to a large number of the interior counties to the northwestward. Quarries have been opened in the Middle coal-measure limestones on the South Raccoon, and on Beaver creek, these beds afford an excellent material for burning into quick-lime. On the Middle Raccoon, in the immediate vicinity of the Panora mills, a very durable rock is quarried, which answers the purposes of heavy, rough masonry. The coal-measure sandstones, as a general thing, are valueless for building purposes, and the same holds true with the Cretaceous sandstones; however, the conglomerate beds of this formation are often so firmly cemented as to form a quite durable, though by no means handsome rock.

The agricultural resources of Guthrie are second to those of no other county in the State. The uplands are covered by a deep, warm soil, and in the western portion of the county the light colored soil peculiar to the Bluff Deposit is met with, which is alike noted for its productiveness and the early maturity of its crops. The valleys of the South Raccoon and Brushy Fork are beautiful tracts of arable land, affording the most desirable locations for stock raising, and possessing

a soil unexceptionably fertile, and capable amply to reward the industry of the farmer. The larger streams afford good mill privileges, which are already being improved in a very creditable manner. Both the Chicago and Northwestern and the Chicago, Rock Island, and Pacific railways are within convenient reach on the north and south, so that Guthrie possesses all the advantages to be derived from railway communications which play so undeniably important a part in developing the resources of the interior counties.

11. GREENE COUNTY.

Greene county lies immediately north of Guthrie and Dallas counties, which form its southern boundary, and is bounded on the west by Carroll, east by Boone, and north by Calhoun and Webster counties. It contains sixteen townships, or an area of five hundred and seventy-six square miles

General Surface Features—Drainage. The North Raccoon river flows diagonally through the county from the northwest to the southeast corner, and its affluents drain the greater portion of the surface, save the extreme southwestern townships, which are drained into the Middle Raccoon through Mosquito and Willow creeks. The principal tributaries of the North Raccoon in this county gain the river on its left or northeastern bank; they are Burrick, Hardin, and Cedar creeks—the two former water the eastern and middle-northern portion of the county, and the latter the northwestern township. On the south side of the river, there are no considerable affluents until reaching the southern tier of townships, in which Greenbrier creek takes its rise and reaches the river just below the southern border in Dallas county.

The Surface Configuration of the county is that of a nearly level plain, the undulations of which are so slight as scarcely to relieve the sameness of the almost boundless prairie landscape. The North Raccoon has excavated its channel to the depth of from fifty to one hundred feet into the detrital materials of the Drift, and is bordered by abrupt acclivities

which give to the valley the peculiar canal-like appearance common to all the larger streams in the northern-central portion of the State. The smaller watercourses, along the greater part of their course, have shallow valleys where beds are but little below the general prairie level.

Springs are not of uncommon occurrence, issuing from the gravel deposits which overlie the drift clays in the steep slopes bordering the streams. Wells are easily obtained at all points, and particularly upon the uplands, where the impervious glacial clays lie at a much less depth from the surface than is the case on the margins of the uplands and in the benches or "second bottoms." The streams afford an abundant supply of clear, pure water.

The Soil is a dark, gravelly loam, and is quite uniformly distributed over the uplands. As a general thing, the low, wet lands that intersect the uplands in the form of swales or "sloughs," can be easily drained and converted into the finest meadow and arable lands. The forests are wholly confined to the valleys and their immediate vicinity. Although the supply of fuel from this source is ample for the present needs, with the rapid settlement of the county the native forests will be inadequate, sooner or later, for the increased consumption of timber for fuel and building, and the inhabitants will have to rely more on the coal deposits, or make early provision for the future demands by planting artificial groves which will thrive as well in this as they are known to in other and adjoining counties.

Geology. The geological formations observed in Greene county belong to the Post-tertiary and coal-measures. There are also peculiar deposits of ferruginous sandstones and fine clay in the northwestern part of the county, which may be referable to the Cretaceous, under which head they are noticed beyond.

Post-tertiary. *The Drift* is extensively developed in this region. Indeed other rock exposures are of very rare occurrence, owing to the prevalence of these extensive detrital accumulations of the Glacial epoch. These deposits consists

of (1st) blue clays, with gravel and boulders distributed through the mass without apparent order in their arrangement. This deposit is overlaid by (2d) a greater or less thickness of loose materials consisting of gravel and sand, sometimes associated with yellow clays, which are more or less distinctly stratified, and which occupy the upland region and usually increase in thickness on approaching the margin of the valleys, where they are terminated in the graceful declivities which constitute so characteristic and pleasing a feature in the valley scenery throughout this region. And, (3d) in the valleys the terraces or benches which rise upon either side of the stream in successive step-like formations to various elevations, and sometimes presenting varied contrasts in configuration. The terraces, or as they are more commonly called "second bottoms," are composed of materials not essentially differing from the surface deposit in the uplands; but in the more definite arrangement of the sand and gravel of the terraces in distinctly stratified order they offer a marked contrast in structure to the modified deposit of the upland. It is due to the porous nature of these deposits that the bench-lands are so little effected by either drought or extreme wet; in the former case the moisture is readily drawn from the reservoirs below the surface, and in the latter the under-drainage is rendered equally effective in carrying off the excessive moisture and discharging it directly into the streams. The alluvial bottoms are narrow, and differ in a marked degree in the character of the materials of which they are composed. The periodic freshets are gradually building up these low intervals by the deposit of mud and sand which form the distinctive peculiarities of their composition. In many parts of the county the Drift deposits probably attain a thickness of from eighty to one hundred feet.

On the north side of the North Raccoon, below Gibson's, in the northwest quarter of section 33, township 84, range 31, a tufaceous deposit was observed at an elevation of about twelve feet above the river and about one foot thick. The

bed is enclosed in yellowish clays which are highly charged with small calcareous concretions recalling similar deposits at the base of the bluff formation in the Missouri valley; and this resemblance is further increased by the appearance of the gravel-bed immediately beneath the tufa, as is so commonly observed in the base of the bluffs in western Iowa along the Missouri bottoms.

Cretaceous. On the North Raccoon river, in the central and northwestern portions of the county, peculiar deposits are met with consisting of soft sandstone and ferruginous grits, and fine variegated clays which bear a marked resemblance to similar deposits in Guthrie county, which have been referred to the Lower Cretaceous. The first exposures of these rocks are found in the neighborhood of Mr. Gibson's, seven miles to the northwest of Jefferson, where a section of about forty feet in height is exposed, consisting of yellowish, more or less ferruginous heavy-bedded sandstone, with obliquely laminated red layers, and cavities filled with an ochreous deposit. This exposure occurs in a ravine on the south side of the river, in the northwest quarter of section 32, township 84, range 31. In the bluffs higher up the ravine, the sandstone forms more durable ledges, portions of which may be employed in ordinary masonry. Variegated, slightly arenaceous clays are also found in this locality a few feet above the river level, and at intervals along the river above Gibson's, light-colored, fine clays appear, which, doubtless, belong to the same deposits. No clue could be obtained relative to the age of these strata more than that afforded by the general lithological resemblance to the Cretaceous deposits in Guthrie county.

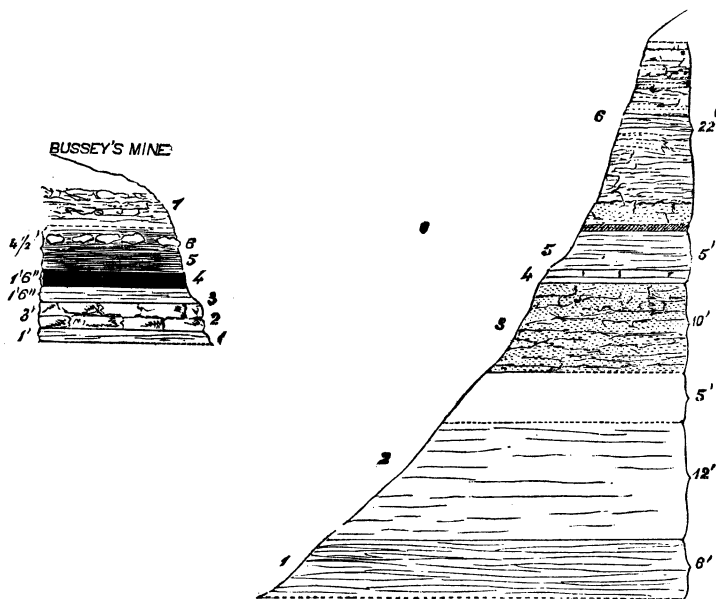
In a ravine a mile west of Jefferson, the Drift Deposits have afforded fragments of light gray, shelly limestone, containing *Inoceramus problematicus*, a common Lamelli-branchiate found in the chalky beds of the Cretaceous, in the environs of Sioux City. But we have no evidence that these higher Cretaceous beds ever existed so far east, the

specimen above mentioned having been brought with other drift materials from a distance.

Coal-Measures. The only exposures of unequivocal coal-measure strata occur on the North Raccoon, in the south-eastern corner of the county, and belong to the lower formation. On Mr. Bussey's place, two and a half miles south of Rippey, in the northwest quarter of section 29, township 82, range 29, the following section is seen in the bluffs on the left side of the valley:

FIG. 83.

Section at Bussey's on the North Raccoon.



No. 6. Light brown and chocolate colored, more or less shaly, sandstone, with imperfectly preserved vegetable remains, *Neuropteris*, and linear leaves, exposed 22 feet.

No. 5. Variegated, light blue and pink colored clay, with pyritiferous band above, 4 feet.

No. 4. Compact, blue, earthy limestone, 1 foot. Contains *Productus aquicostatus*.

No. 3. Light arenaceous shales, with sandstone above, 10 feet.

No. 2. Light yellow clays, exposed 12 to 17 feet.

No. 1. Blue, ferruginous, indurated shales, exposed to level of river, 6 feet.

In the bed of a ravine in the northeast quarter of section 30, a few hundred yards above the preceding section, at Bussey's coal-bank, an eighteen inch bed of coal crops out, where it is associated with the following strata:

Section at Bussey's Coal-Mine.

No. 7. Debris of shaly sandstone.

No. 6. Irregular band of *septaria*, enclosed in blue clay, $1\frac{1}{2}$ feet. The nodular *septaria* contains numerous fossil remains, including the following forms:

Productus æquicostatus, *P. muricatus*, *P. longispinus* (?), *Chonetes mesoloba*, *Martinia planoconvexa*, *Discina*, *Lingula*, *Nucula*, *Solenomya radiata*, and one or two other species of *Lamellibranchiata*, *Macrocheilus*, *Pleurotomaria sphærolata* (?), *Bellerophon carbonaria*, *B.* (sp. ?), *Orthoceras*, *Nautilus*, *Goniatites*.

No. 5. Carbonaceous shales, 3 feet. Contains the imperfect remains of one or two species of *Lepidodendron*, and impressions of linear leaves in that portion of the layer immediately above the coal. In the upper part of the bed are found *Bellerophon carbonaria*, *Leda bellastrata*, *Productus*, minute species, *Chonetes mesoloba*, *C. Verneuilianus* (?), *Discina*, Polyzoa, crinoid stems.

No. 4. Coal, 18 inches.

No. 3. Blue clay, 18 inches.

No. 2. Compact, bluish limestone, 3 feet, with *Productus*, *æquicostatus*, *P. Nebrascensis*.

No. 1. Yellow shales, exposed in bed of ravine, 1 foot.

The coal-bed at Bussey's mine is about twenty-four feet above the river, and it is said to have a slight dip to the northward. The bed, however, is much disturbed—large blocks of coal were found tilted on edge and other signs of confusion were encountered in driving the entry into the bank. On the south or opposite side of the ravine the bed entirely thins out. The coal is highly charged with pyrite, and is said not to improve in quality on working into the bank. The relation this bed holds to the exposures exhibited in the preceding section, is not satisfactorily determined. It is possible, however, that the limestone bed seen at that exposure is the same as that underlying the coal at Bussey's mine. A few yards higher up the ravine shaly sandstones are found which are identical with the upper beds of the former section; and taking into view the dip of the coal to the northward and its thinning out in the opposite direction, it is very probable

that the horizon of the undeveloped coal is represented by the shales (No. 5), in the bluff outcrop. In the palæontological characters of the beds associated with this coal horizon, it bears a close resemblance to the bed worked by the Moingona coal company, on Polecat creek, near Boonesboro.

Five or six miles below Bussey's, in the extreme southeast corner of the county, on Bower's branch, several distinct exposures of coal occur within a vertical height of twenty-five feet. The outcrops are limited, and it is possible the beds have a northerly inclination, in which case there would be a much greater thickness of strata intervening between the coals than is apparent from the relative levels of their outcrops, which are, perhaps, a quarter of a mile distant from one another. The first or lowermost exposure appears in the left bank of the North Raccoon, a few yards below the mouth of Bower's branch, in the southeast quarter of section 36, township 82, range 29, at which place the following section was made:

- No. 4. Yellow and blue clays, exposed 7 feet.
- No. 3. Bituminous shales, $1\frac{1}{2}$ feet.
- No. 2. Coal, $1\frac{1}{2}$ feet.
- No. 1. Ash colored shale, exposed to bed of river, 4 feet.

The coal is exposed only at low water. No organic remains were observed in the bituminous shales.

Ascending Bower's branch, the next exposure is seen in the left bank at what is known as Utter's coal-bank, in the southeast quarter of section 36. Here a ten inch coal-bed outcrops about twelve feet above the level of the coal at the preceding locality, and presents, essentially, the same strata as shown in the former section. A few hundred yards above Utter's, a thin coal-bed appears in the south side of the ravine at Bower's coal-bank, the coal being some seven feet above the level of that at the last mentioned exposure, and presenting the following section:

Section at Bower's Coal-mine.

No. 5. Light yellow shales, exposed 5 feet.

No. 4. Dark blue, irregularly bedded or nodular limestone, sometimes in *Septaria* masses, embedded in blue clays, 1 foot. Contains—*Productus semireticulatus* (?), *Chonetes Verneuillianus*, *Hemipronites crassus*, *Orodus*, (sp. ?).

No. 3. Black carbonaceous shales, 1 foot. *Productus longispinus*, *P. Nebrascensis*, *Chonetes Verneuillianus*, *Hemipronites crassus*, *Athyris subtilita*.

No. 2. Coal, 10 inches.

No. 1. Light, ash-colored clay, exposed to bed of ravine, 1 foot.

The last described exposure is doubtless distinct from either of the preceding—differing not only lithologically, but also in the fossils contained in the carbonaceous shales, and in the overlying band of limestone. Amongst the debris in the bed of the branch at Bower's mine, fragments of buff magnesian limestone, evidently derived from the Drift, were found, which contain a Gasteropod and *Pentamerus* (?), but too obscure to identify, though the rock is probably referable to the Niagara limestone formation.

Economical Geology. *Coal*, so far as it has been possible to learn, is not widely distributed over the county. The beds that have been discovered at the surface, are thin and not of the best quality, taking as a standard of comparison even the western coals. That other and better beds may be found by shafting, we have no reason to doubt. Indeed, the greater portion of the county may be underlaid by the coal-producing formation, but as yet we have no data showing conclusively that this is the case.

Peaty Accumulations are known to exist in the low swales in the uplands at various places in the county. But these deposits are so shallow and intermixed with sand from the washings of the adjacent Drift Deposits, as to be valueless for fuel. These marshes, however, have little resemblance to the peat-marshes of Northern Iowa, the vegetation being in no way different from that which grows upon all more or less moist tracts; while in the peat region of northern Iowa, as the investigations of Dr. White has shown, the wire-grass

forms the most striking peculiarity to the casual observer in the appearance of a peat bog.

Building Stone is scarce in the county. There is comparatively little good quarry rock, the sandstones usually being too friable to answer even for the most ordinary purposes of masonry. Materials for the manufacture of common brick are abundant; and to this source we must mainly look for the local supply of building material in the county. At Jefferson, a company has manufactured a quantity of concrete blocks, but with the experience at present before us, we can hardly recommend the concrete, as it is now manufactured, as a durable building material. Processes may, and doubtless will, be perfected after more experience shall have been acquired, when an article as imperishable as stone may be produced in this convenient shape.

In the bottoms upon the west side of the North Raccoon, seven miles above Jefferson, on Mr. Gibson's farm, a very symmetrical mound rises from the plain, which has every appearance of an artificial work. The mound is about twelve feet in height and seventy-five feet in diameter, and is composed of the gravelly soil found in the bottoms upon which it rests. Mr. Gibson informed me that before the field was subjected to cultivation, a very shallow but well marked depression encircled the mound, but which is now hardly discernable. There were formerly several other and smaller mounds in the same field, but these have been leveled by the plow. On the bluffs opposite, other mounds are found which are said to have contained human remains.

Possessing a productive soil, and good railroad facilities, the rapid growth of Greene county during the past five years are substantial auguries for her future prosperity and agricultural eminence.

12. CARROLL COUNTY.

Carroll county adjoins Greene on the east, Guthrie and Audubon on the south, Crawford on the west, and Calhoun and Sac counties on the north. The county comprises

sixteen townships, or an area of five hundred and seventy-six square miles.

General Surface Features. Lying upon the Great Watershed, the county is watered by streams which flow into the Missouri on the west, and into the Mississippi on the east. The North Raccoon, which cuts across the northeast corner of the county, is the largest stream; the Middle Raccoon and the Brushy fork are the two next in importance. The two latter streams take their rise in the watershed divide in the northeastern portion of the county, and flowing nearly parallel four to six miles apart in a southeasterly direction, they make their exit near the southeast corner of the county. The upper courses of these streams are little more than diminutive prairie brooks, with gravelly beds, and clear, rapid currents. Storm creek, an affluent of the Middle Raccoon, drains a large tract in the northern-central portion of the county, as also does Willow creek, on the eastern border. The North Raccoon is deeply excavated into the Drift Deposits, and its valley is bordered by rather steep acclivities, from seventy-five to one hundred and more feet in height. The Middle Raccoon is bordered upon its west margin by the high bluff-capped slopes, while on its east side the Drift hills are less conspicuous, and gain the inland heights by more gradual ascents. Brushy fork possesses a beautiful little valley, with gentle acclivities upon either hand. On the west side of the watershed divide the headwaters of the East Nishnabotany, Whitted's creek, and the East Boyer river rise, and form a drainage system rarely more perfect. The headwaters of the streams on either slope of the Great Divide interlock, as it were, the drainage in many places being separated by a narrow crest, as sharply defined as a gable-ridge. The eastern slope from the summit of the watershed is quite rapid. From profiles constructed by Mr. Charles W. Irish, C. E., from levelings on the Chicago and Northwestern Railway line, the descent from Tip-Top to the water-level of the North Raccoon, at the point where it leaves the county, is shown to be about four hundred feet. The eastern portion of the

county has a gently undulating surface, but to the westward of the Middle Raccoon, the surface presents a more rolling appearance.

Springs issue from the gravel deposits of the Drift along all the watercourses, furnishing the stream an abundant supply of limped, pure water. Wells are easily obtained in the region east of the Middle Raccoon, but in the uplands west of that stream, water must be sought at greater depths, though with just as great certainty of finding a never-failing supply.

In a shallow depression or plain, below Carrollton, on the east side of the Middle Raccoon, several interesting spring-mounds occur which have excited much attention. The plain is thirty to forty feet above the present level of the river, from which it is separated by a well-defined drift ridge which, in places, rises into considerable knob-like eminences from one hundred to one hundred and fifty feet above the stream. The plain, however, communicates with the valley both above and below, and was probably once the channel of the river. The spring mounds are situated along an irregular line more or less in the middle of the depression; they are from four to six feet in height and as many yards in diameter, and are apparently entirely composed of vegetable matter, forming a peaty deposit which is largely mixed with the exuviae of shells and other animal remains. The crests of the mounds are covered by a rank growth of tall, flag or marsh grass, but upon the sides there are usually two well-marked bands of short herbage and moss encircling the mounds and separated by a narrow belt of taller grass. The disposition of the vegetation upon these places is exceedingly interesting, though the mounds themselves, doubtless, owe their origin to the existence of pools of water, indicating, more or less accurately, the course of a former water channel, and which, being fed from higher sources, the tendency is what we observe—a gradual building up of a peaty formation. The surface of the plain beyond the limits of the mounds is perfectly level, and the deposit consists of decayed

vegetable matter mixed with sand, forming a sandy muck. Limited peaty deposits occur at several other localities in the county, but none have been discovered of sufficient extent to justify much dependence being placed on this resource for fuel. These deposits are confined to springy ravines, and higher up the watercourses, to low swales or "sloughs."

The Soil of Carroll county, like that of Guthrie county, presents two well-marked varieties. East of the Middle Raccoon, the Drift Deposits have furnished a gravelly loam of great strength and productiveness; while to the west of that stream the uplands are deeply enveloped in the Bluff formation which has imparted to the soil of this portion of the county its own peculiar characteristics. On the principal streams, small groves of native forest are found, and in favorable situations, even upon the uplands, forests of young oaks are springing up. In the valley of the Brushy Fork, two or three small groves are met with, and between Raccoon rapids and Carrollton, on the Middle Raccoon, other and more extensive tracts are covered with fine growths of forests.

Geology. The only rock formations thus far known to occur in Carroll county, belong to the Post-tertiary and Cretaceous periods.

Post-tertiary. The *Drift* Deposits are well developed in the county, attaining a thickness of above one hundred feet. The glacial or blue clay deposits are found in all these broad depressions in the northern and eastern portions of the county, where their presence may be readily distinguished by the less gravelly character of the soil, as also by the greater prevalence of moisture in these localities. The modified gravel-beds overlying the glacial clays are accumulated along lines between the drainage depressions, forming low and more or less well defined ridges, whose surfaces are strewn with the coarse materials of which they are in part composed, and which consist of pebbles and boulders of granitic gneissose, red quartzite, and limestone rocks. On the east side of the Middle Raccoon the gravel deposits rise into quite prominent ridges and mounds, which terminate abruptly on the river

face, and slope quietly inland. This dike like drift-ridge forms a peculiar feature in the topography of the country bordering the Middle Raccoon throughout the greater part of its course. It confines the river to a narrow, gorge-like valley, and turns the drainage into a few far less considerable, though on this account doubly important, affluents which discharge into the main stream at intervals the waters gathered from a large area.

The valleys of the North and Middle Raccoon rivers are beautifully terraced, the materials of which are arranged in the most perfect order, though presenting all the varieties of deposition, such as more or less confined currents produce, as is well known in the examples of the alluvial formations now in process of making. The terraces vary in elevation above the present levels of the rivers, of from ten to thirty or forty feet, and occupy the greater portion of the valleys. Fine examples of these formations may be seen on the Middle Raccoon in the vicinity of Carrollton and below, but above that point they become less and less marked, and finally disappear entirely.

The Middle Raccoon and Brushy fork are separated by a sinuous, rounded divide which attains an elevation upwards of one hundred and fifty feet. The latter stream differs widely from the former: its valley is not terraced, and the bottom-lands gradually and interruptedly ascend to the steeper acclivities which bound the valley on either hand. The gravelly soil of the sloping bottoms is largely mixed with the fine material derived from the Bluff Deposit, which crowns the heights bordering both sides of the valley. In the divide between this stream and the Middle Raccoon, the Drift Deposits reach the height of one hundred and thirty feet above the stream, and the Bluff Deposit thence to the summit shows a thickness of thirty feet in many places. The line of demarcation between the Bluff and the Drift Deposits is usually obscured by the washings of the upper deposits, which sometimes cover entire slopes underlaid by the Drift. But there are localities where the limits of the deposits may

be distinctly seen, as in the valley-side near Mr. Cooley's opposite Fuller's grove—township 82, range 34. The west margin of the Brushy Fork is bordered by rather abrupt low bluffs, from which the ascent swells in graceful undulations to the elevated watershed divide in the western portion of the county. The following diagram conveys a tolerably accurate idea of the configuration of the country in the border region of the Bluff and Drift Deposits, the elevations being approximately accurate:

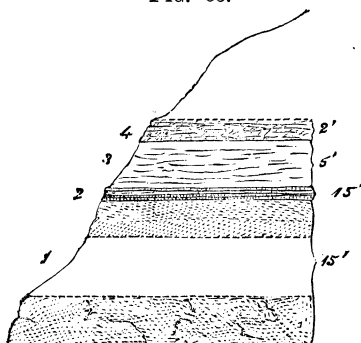
FIG. 84.



The above profile represents the surface contour along the southern border of the county. The dotted line approximately indicates the division between the Bluff and Drift Deposits, which deeply cover the watershed and cap the divide between the Brushy fork and the Middle Raccoon. On the right, is shown the drift-ridge bounding the east side of the Middle Raccoon, from which it separates the broad depression in which the peaty spring-mounds before mentioned occur.

Cretaceous. On the North Raccoon, in the northwestern portion of the county, there are a few exposures of soft ferruginous sandrock, &c., which are referred to the Cretaceous. In the right bank of the river, near Mr. Shrive's, in the southeast quarter of section 9, township 84, range 32, a thickness of ten feet of soft, heavy-bedded yellow sandstone outcrops at an elevation of thirty feet above the stream. The rock is worthless for building purposes, readily crumbling between the fingers and rapidly disintegrating from exposure. On Purgatory creek, in section 12 (?), township 85, range 33, similar soft ferruginous sandstone exposures

Fig. 85.



occur, underlaid by fine, light clays, which doubtless belong to the same formation.

At Raccoon rapids, in the right bank of the Middle Raccoon, a fine exposure of sandstone, clay, and ferruginous layers afford the following section:

Section at Raccoon Rapids, Middle Raccoon.

- No. 4. Hard, shaly, ferruginous sandstone, exposed 2 feet.
- No. 3. Ash-colored clays. 5 feet.
- No. 2. Alternating ferruginous sand and clay bands, 15 inches.
- No. 1. Soft, light and brown, laminated sandstone, passing below into heavy bedded yellow sandstone, exposed to river level, 15 feet.

One mile south of Carrollton, in the northeast quarter of section 12, township 82, range 34, a ledge of heavy bedded, soft, ferruginous sandstone forms a low mural exposure for several yards along the left margin of the stream, where it shows a thickness of about twenty feet. In the lower portion of the bed, large lenticular masses of light colored fine clays occur sometimes several feet in length, the washing out of which has produced miniature caverns in the base of the escarpment. The clay is not unlike that usually associated with the Cretaceous sandstones a few miles south in Guthrie county, and the entire lithological resemblance to those deposits is too unmistakable to allow of a doubt respecting their identity. Mr. McCredy, of Carrollton, also showed me other exposures in this vicinity which, without doubt, are referable to the same formation. The clays often present dark colored, arenaceous layers which have been mistaken for coal-measure shales. Although the coal-measure strata are not seen at the surface they probably underlie a portion of the southeastern half of the county.

and perhaps even a larger portion of its area. About three-quarters of a mile southwest of Carrollton, in the right bank of the Middle Raccoon, about six feet above the water, a gray, fragmentary, impure limestone outcrops, showing a thickness of three feet and underlaid by fine ash-colored clays. No organic remains were detected in the limestone, and its relation to the former exposures is not known.

Economical Geology—Coal. The only coal known to occur in the county is that derived from the Drift Deposits; in digging wells and making other excavations, fragments have been found associated with the loose materials of these deposits. But no beds of this important mineral fuel have as yet been discovered, though it is not deemed improbable that the coal-measure formations underlie at least a portion of the county, yet we have no positive evidence to that effect.

Peat, or Peaty Deposits are known to exist at several localities in the county. Just below the mill at Raccoon rapids, in the bed of a slight ravine on the west side of the river, an accumulation of peat, several feet in thickness, was found, but it is too limited to be of any value. The peat rests upon the blue clay of the Drift, and is confined on three sides by the loose gravel deposit. Near Mr. Robert Hill's place, on the headwaters of the Brushy Fork, section 36, township 83, range 35, similar accumulations have taken place in the swales which intersect the prairie upland, and the turf is said to burn well. These deposits are of considerable extent, and should they be found to be free from sand and gravel, they may become of some value as a resource for fuel.

Building Stone is very scarce in the county. The Cretaceous sandstones are too friable to answer for the most ordinary building purposes, excepting some of the harder ferruginous layers which are sometimes employed in laying up rough under-pinnings and in walling up wells, &c. The materials for making brick may be had in abundance. But care is necessary when the selection is made in the western portion of the county, in consequence of the prevalence of calcareous matter derived from the disintegration of the

Bluff Deposit in the surface deposits upon the lower slopes. The lime thus mixed with the earth is converted into quicklime in the process of burning the brick kiln, and on exposure to moisture the lime slakes and bursts the brick.

The county is traversed east and west by the Chicago and Northwestern railway, so that lumber for building purposes and other improvements is as easily and cheaply obtained as in any of the interior counties. In common with many other counties, Carroll offers some of the most desirable facilities for stock raising, and the soil is capable of rendering the most remunerative returns for careful husbandry. The streams are small, though they may be turned to great practical account as furnishing water-power. That at Raccoon rapids is one of the best in this section of the country.

13. CALHOUN COUNTY.

This county comprises sixteen congressional townships, or an area of five hundred and seventy-six square miles. It lies wholly upon the Mississippi slope, and is bounded on the east by Webster, on the north by Pocahontas, west by Sac, and on the south by Greene and Carroll counties.

General Surface Features. The general surface configuration is nearly level, or but gently undulating, and with the exception of occasional small groves in the neighborhood of the streams, its entire surface presents an uninterrupted prairie.

The county is mainly watered by the North Raccoon river and its tributaries. The former stream crosses the southwest corner of the county, where it receives Lake and Camp creeks. The South fork of Lizard river crosses the extreme northeast corner of the county, collecting the drainage of two or three townships in that quarter. The streams have shallow though well-defined valleys, which are almost entirely excavated in the Drift Deposits, and are bordered by narrow bottoms from which rise rather steep acclivities. The valley of the North Raccoon in the vicinity of Lake City has a depth below the bordering uplands of from eighty to

one hundred feet. But the smaller streams rapidly ascend, and along their upper courses they often spread out into wide, marshy tracts, though still retaining the character of distinct drainage channels. Upon the level uplands are found tracts of wet land, but these can be easily drained, and when once reclaimed they will comprise the most valuable lands for agricultural purposes in the county. The higher tracts are covered by a dark, gravelly loam, capable of producing excellent crops of all kinds adapted to this latitude.

Twin Lakes. In the northern-central portion of the county, are two handsome lakelets, comprising within their margins an area of about seventeen hundred acres. They are shallow basins but slightly depressed below the general level of the adjacent prairie, and are bordered by low indented shores which here and there jut out into the water forming miniature headlands, five to twenty feet in height. In places the shores are studded with boulders, and along the low places embankments, of earth have been crowded up from the bottom by the expansive force of the ice in winter, forming in both cases accumulations bearing some rude resemblance to walls. Their beds are sandy or gravelly, and covered with a depth of from five to twenty feet of water, and abundantly supplied with fishes of the same species as those found in the streams in this region.

The north lake is a narrow body of water about two and a half miles long, with an average width of half a mile. Its shore line is interrupted by miniature headlands and shallow bays with short stretches of sandy beach and plots of rushes. The south lake is more quadrangular in outline, with a marshy arm running parallel with the south margin of the upper lake from which it is separated by a narrow strip of land. Just to the west of this lake is a large marsh, which was once, doubtless, a third lake and is still connected with the south lake by a shallow outlet at its upper extremity. The longer axes of the lakes are on a nearly northeast and southwest direction. They were once connected by a wide

shallow arm at the south end of the upper lake forming a continuous sheet of water four miles in length. But at no very remote period, comparatively, the connection between the lakes was cut off by the formation of low barriers of sand on either hand, by the same agencies that formed the walls, enclosing a shallow basin which was subsequently converted into a marsh. Early in the season of 1869; the upper lake burst the barrier on the east margin near its foot, producing a diminutive channel connecting it with the south lake. The drainage of the lakes is affected through a "slough" commencing at the foot of the lower lake, which discharges into Lake creek, an affluent of the North Raccoon.

Peaty Deposits are not unfrequent, though none of any considerable importance have as yet been discovered. Those that have been examined were found to be of limited extent and largely mixed with sand and other foreign matter, in consequence of which their value for fuel is greatly lessened. However, it is not improbable that a thorough examination might bring to light important deposits of this material. On Mr. David Haines' place, in section 7, township 86, range 34, a peaty accumulation is found in the brow of the bluff overlooking the west side of the valley, which is several feet in thickness. It is formed along the line at which the springs issue from the gravel beds, and is gradually increasing by crowding down the slope, or following the course of the moisture and terminating abruptly at the point where the spring waters again sink into the loose deposits forming the terraces or high bottom-lands.

Geology. Aside from the Drift of the Post-tertiary period, there are exceedingly few rock exposures in the county, and these are of limited extent and doubtful age.

Post-tertiary, The deposits of the Drift are well represented, everywhere covering the surface of the county to the depth of from fifty to upwards of one hundred feet. They consist of the boulder-charged, glacial clays, upon which rests a deposit of loose, coarse materials, which bear in their

bedding evidence of their modified origin. In the valleys of the larger streams these coarse materials have undergone further modifications during the time in which the terraces, or "second-bottoms" were formed, which to-day constitute one of the most pleasing features in the valley scenery. Fine examples of terrace formations are found in the valley of the North Raccoon, and wherever the stream has cut into these benches, exposing a section of their structure, they are invariably found to be made up of well assorted materials, presenting almost every conceivable variety of stratification in their arrangement. The terraces are composed of sand and gravel, and usually being above the reach of the highest floods, they comprise valuable tracts for agricultural purposes.

The loose materials or gravel deposits which occur at the surface in the uplands, are very generally distributed, though they form a deposit of very variable thickness. Wherever they occur, however, the soil is thoroughly underdrained, so that the presence of this deposit is most beneficial by rendering the greater portion of the lands accessible for immediate cultivation. But wherever the glacial clays come to the surface, lakes and boggy land or marshes occur, the drainage of which, owing to the impervious nature of this deposit, is only affected by means of direct channels or water-courses.

Cretaceous. In the extreme southwest corner of the county, on the Lower course of Lake creek, limited exposures of soft, ferruginous sandstone, accompanied with clays, is said to appear, which, doubtless, belong to the sandstone formation that outcrops on the North Raccoon, in Greene and Carroll counties. These deposits are of doubtful age, no fossils as yet having been detected by means of which the stratigraphic position of these beds could be determined. But there seems to be good grounds for referring these sandstones to the Lower Cretaceous epoch which, we know to be represented by similar deposits on the Middle Raccoon, a few miles to the southwestward in Carroll and Guthrie counties, and on North Raccoon, in the adjoining counties of Sac and Greene.

The Lower coal-measures appear on the Lizard and on the Des Moines, in Webster county, which joins Calhoun on the east. This formation may possibly underlie at least a portion of the region embraced within the limits of this county; but the heavy deposits of Drift that everywhere cover the surface, conceal from view every vestige of this formation, unless the sandstones mentioned above, belong to the coal-measures. Yet these latter deposits are quite unlike the sandstones that occur in connection with the coal in the Fort Dodge region, though they have an unmistakable resemblance to the arenaceous beds which are associated with, or found overlying the gypsum deposits at that locality.

General Observations. There being no coal-beds in Calhoun county, the supply of fuel is wholly derived from the forests. These are limited in extent, compared with the extent of surface destitute of trees. However, this fault can be easily remedied by the planting of artificial groves. The common willow has been successfully cultivated for hedges, making in a few seasons a very secure fence. The materials for the manufacture of brick are abundant, and will constitute the principal building material where wood is not employed. For grazing purposes, the county is one of the best in the State. Water for stock can be easily obtained, and those portions of the surface that now present almost impassable sloughs, by a thorough system of drainage, may be converted into the most valuable lands for meadows.

14. SAC COUNTY.

Sac county has an area of five hundred and seventy-six square miles. The general form of the county is square, but the northern tier of townships, north of the correction line, form a slight offset two and three miles west of the southern ranges. It joins Calhoun on the east, and is bounded on the north by Buena Vista, west by Ida, and on the south by Carroll and Crawford counties.

General Surface Features—Drainage. The county is principally drained by the North Raccoon and Boyer rivers. The

headwaters of Maple river rise on the western border, though the main part of the drainage is performed by the two former streams. The Boyer river takes its rise on the northern boundary of the county, and flows southerly through the thirty-seventh range of townships or nearly through the middle of the county. The North Raccoon, the more important stream of the two, rises in Buena Vista county, one of its sources being Storm lake, and flowing in a southeasterly direction it leaves the county on the eastern border of the southeastern township.

Surface Configuration. The position of the county being upon the Great Watershed, dividing the drainage of the Mississippi and Missouri rivers, its surface features are more varied than those found in the county last described. The watershed divide passes through the middle of the county in a north-south direction, and forms a well defined plateau-like ridge varying from one to five miles in width. The eastern face of the divide sometimes presents an abrupt acclivity overtopping the highest ridges to the eastward, in which direction an extensive view is gained overlooking the basin occupied by the North Raccoon and its tributaries. This basin presents the appearance of a broad plain, which is traversed in a north and south direction by low ridges or benches, which are more or less parallel to one another. To the southward, a higher ridge running eastward and apparently connected with the main watershed divide, forms a conspicuous barrier, separating the headwaters of the Middle Raccoon from the North Raccoon river. This ridge lies within Carroll county, a few miles to the southward of Wall lake, and is a prominent land-mark in that quarter. The west slope of the great divide descends into the valley of the Boyer by a more uniform declivity, though perhaps, no less abrupt than is the eastern face in many places.

There is a marked contrast between the valleys of the east and those of the west side of the watershed, though it is one commonly observed throughout this region. However, it has been shown in the notice of Guthrie and Carroll counties, that

even the country upon the east slope of the great divide, for at least a few miles to the eastward of the crest, partakes of the topographical characters common to the west side. This is due to the overlapping, as it were, of the Bluff Deposit upon the Mississippi slope along that portion of the main divide. But in Sac county, the watershed marks the eastern limit of that deposit, as it also separates the two topographical features belonging to the Drift and Bluff Deposits by a distinct, even abruptly drawn line. The valleys proper, on the east side of the great divide, are comparatively shallow, and are bordered by rather abrupt acclivities. The valley of the North Raccoon, in the vicinity of Sac City, has a depth below the adjacent uplands of from fifty to seventy feet. Throughout its course in the county, it presents beautiful examples of terraces, varying in elevation above the level of the stream from five to thirty-five feet. Sac City, owes the beauty of its location to one of these terraces, or "second bottoms" as they are often termed—which here occupies a large portion of the valley upon the west side of the river, forming a plain thirty to thirty-five feet above the river level—even the aboriginal inhabitants of the country seem to have appreciated the natural beauty of these locations, and in many instances they were selected for village sites or places for the interment of their dead. The present village of Sac City occupies what appears to be one of these burial grounds. A series comprising six or eight low, circular mounds, varying from fifty to eighty feet in diameter and two to six feet in height, without apparent order in their arrangement, occupy a portion of the terrace facing the southeast. Several of the mounds have been excavated into, without however, any discovery being made that throws any light upon their origin or the purpose for which they were erected.

Above Sac City, the North Raccoon valley rapidly becomes more shallow, until, on reaching the northern line of the county, it assumes all the characteristics of a prairie brook. Cedar creek, the most considerable affluent in the county, falls into the North Raccoon upon its left margin, a mile or

so below Sac City. All the streams on the east side of the watershed possess clear, rapid currents, and sand or shingle beds. The principal stream furnishes fine mill-sites, which will become important auxiliaries in developing the resources of the country as its settlement progresses.

The valley of the Boyer presents an entirely different aspect from that of the North Raccoon. Its bottom land varies from a quarter to half a mile in width, through which the stream oscillates from side to side, resembling a deep, narrow ditch bordered by steep, muddy or grassy banks. The bottom lands gently rise to the foot of the uplands, which have a regular and rather steep ascent the lower third of their height and thence to the summit the ascent is gradual, giving rise to the beautiful tracts of undulating upland so frequent in this region. All the tributaries of the Boyer within Sac county are short, being indeed little more nor less than shallow ravines, whose beds are seldom flooded, save during heavy rains, or in the spring when the melting of the snow converts their beds into diminutive rivulets.

To the westward, the land rises in the divide between the Boyer and Maple rivers, which is intersected by numerous ravines and drainage channels tributary to the latter stream, whose beds are deeply eroded into the surface deposits, producing all along the western border of the county a belt of rolling land.

Lakes. With the exception of a few small ponds in the center of the county on the upper course of Indian creek, there is but a single body of still water that can be properly classed under this head. This little sheet of water is situated in an undulating knob in the Drift region between townships 86 and 87, range 36, in the southern portion of the county, and is known by the name of Wall lake. The longer axis of the lake lies in an east and west direction, its eastern portion is the widest, contracting in the middle by a narrow point of land which puts out from the south shore, and expanding again to the westward probably two or three square miles within its margins. It occupies a shallow

basin resting upon the Glacial Deposits, its bed being very uniform, and composed of mud or sand, with a depth of from five to twelve feet of water. In places, the shore is bordered by low embankments of earth and boulders, which are often broad enough on the top for the passage of carriages, forming beautiful natural road-ways, fringed at intervals by clumps of low shrubs and pretty stretches of sand beach upon the one hand, and the grassy prairie upon the land side. At the eastern extremity, in the vicinity of the outlet, the shore is exceedingly low, the lake margin being here defined by a low turf barrier, which owes its origin to the same natural causes that threw up the sand and boulder embankments. In settled weather the water is quite clear, and of a deep blue color; but during the prevalence of storms and the consequent agitation of the lake, its waters become thick and turbid with the fine sediment stirred up from the shallow bottom. The land gently rises on all sides of the lake, the highest eminences reaching an elevation of from seventy-five to ninety feet above the water. The land is perceptibly lower in the direction of the outlet, which drains into Indian creek, an affluent of the North Raccoon. The lake is abundantly stocked with fish, and during the spring and autumn months it is the resort of myriads of water fowl.

Forests, Soils, etc. The wooded portion of the county is almost wholly embraced in the valley of the North Raccoon. In the vicinity of Sac City and Grant, and at intermediate points, handsome groves line the banks of the river, and here and there spread out over considerable tracts on the higher terraces and uplands. The Boyer valley is almost destitute of trees, an occasional clump of willow and other low growth is all that bears any resemblance to arboreal vegetation. With the settlement of this region and the consequent introduction of trees, the whole face of the country will undergo a change in its appearance which only those who have been familiar with it in its original, wild prairie condition, will have any just appreciation of.

The soil, over the whole eastern half of the county, is a

gravelly loam, as might be expected in a region where the Drift Deposits, from which the soil is derived, present their finest development. Upon both sides of the North Raccoon, there is a narrow belt of knobby lands where the soil is more than usually gravelly, and the surface on the higher knobs and ridges is often thickly strewn with boulders. In the lower grounds and depressions, we find a very fertile accumulation of black soil containing just enough coarse materials in its composition to render it tractable under cultivation. The bench or terrace lands in the valleys, have a soil quite peculiar to those situations, the component parts of which consist largely of fine gravel and sand remarkably evenly distributed with a liberal admixture of humus. The intervals or low bottoms immediately bordering the larger streams, as usually observed throughout this region, are made of sand deposited by the annual freshets and the wash from the adjacent uplands. In the western portion of the county, the fine, yellow soil of the Bluff Deposit prevails almost exclusively.

Wells of good water are easily obtained in the region of the Drift, and even in the western portion of the county, water can be found doubtless at moderate depths by excavating through the Bluff Deposit to the underlying Drift gravels. In the country drained by the North Raccoon, springs are very common, appearing at all elevations in the valley slopes; but the limped streamlet soon loses itself in the loose, porous deposits that fill the valley.

Geology. So far as known at present, no rocks of older age than the Post-tertiary period appear at the surface in Sac county. Possibly the coal-measures underlie at least a portion of the county, but at the same time it is deemed hardly probable. Also, the Cretaceous formation may occupy a portion of its area, since in the adjoining counties to the east and south the sandstones provisionally referred to that period are known to occur, the last exposure of which, that is seen on the North Raccoon, is but three or four miles east of the eastern boundary of Sac county, in section

22, township 86, range 34, Calhoun county. But none of these formations have been recognized within Sac county.

Post-tertiary. The entire surface of Sac county is deeply covered by Post-tertiary deposits, which present all their varied physical peculiarities to great advantage. The Drift or older deposits of the period occupy the surface over fully half the area of the county. The Glacial Deposits, consisting of blue clays, sand, and gravel, with boulders, may be seen at numerous points in the sides of the deeper valleys. Resting upon these deposits are almost equally widely distributed deposits of modified drift materials which occupy the surface, and almost everywhere form the subsoil in the uplands. The latter deposits are made up of the coarse materials derived from the breaking up or erosion of the glacial beds and their re-deposition in shallow waters affected by currents, as evidenced by the more or less distinctly stratified condition of these superficial beds. These deposits, however, have been subjected to very extensive erosion, greatly reducing their original importance, but leaving here and there landmarks that enable us to form some conception of their former extent. These remnants exist in many instances as knobs and low ridges that rise above the general level of the surrounding country, and are peculiar for the great prevalence of boulders in their immediate vicinity, and with which their tops and sides are thickly paved. In the intermediate depressions between the gravel ridges where the drift deposits have been denuded to greatest extent, the heavier and coarser materials, such as the currents could not remove to any great distance, have accumulated in the trough, so to speak, and in the course of the subsequent great length of time they have been covered and hidden entirely from view by the wash from the surrounding high grounds. In digging wells in these depressions, which still retain a more or less well-marked existence in the surface conformation, the accumulated mass of boulders are often encountered and sometimes prove serious obstacles in making excavations for water.

As we approach the Great Watershed in the central portion of the county, the Drift Deposits must attain a thickness of two hundred feet or more. They appear in the highest eminences immediately upon the eastern margin of the great divide, forming steep declivities, in whose sides the gravel and boulders prevail in abundance. In the region between the Watershed and the North Raccoon, the surface falls away in broad undulations, like gigantic terraces, the crests of the parallel ridges or swells being broken into knobs, and, in places, strewn with boulders and gravel. Just before gaining the North Raccoon, the surface gracefully sweeps upwards, and then suddenly breaks down, forming ranges of low bluffs bordering the valley.

In crossing the great divide, we hardly gain the summit when the Drift disappears—no boulders, indeed not so much as a pebble is visible at the surface, but instead, the light buff deposit of the Bluff formation everywhere meets the eye. At first, but a film overspreads the Drift Deposits along the eastern margin of the divide, but it increases in thickness as we approach the higher portions of the divide, where it is probably several feet in depth, completely burying the underlying deposits from sight. However, at infrequent intervals, the Drift again appears in the slopes overlooking the Boyer valley, but the Bluff Deposits crowns the higher grounds and also generally envelopes the valley declivities; and to the westward, in the divide between the Boyer and Maple rivers, it constitutes the predominant geological and topographical features of the country.

General Observations. — Building Material. With the exception of the boulders in the Drift Deposits, there is no stone in the county. Material for making common brick is abundant, but the present scarcity of fuel in the greater portion of the county prevents even this resource being made so available as it might be under more favorable circumstances. Should a process be discovered for manufacturing a durable "concrete block," the gravel beds which abound over so large an extent of the county could be turned to

great economic account as furnishing a building material. The demand for lumber for building purposes is now promptly supplied by the railways which approach both the north and the south borders of the county within twenty miles of the most remote settlements.

As a grazing region, Sac county has no superior in the State. It will also eventually take a high rank as a grain producing county. But it is peculiarly adapted for stock raising, which will, doubtless, in the future, engage the chief interests of the farming community.

15. IDA COUNTY.

This county lies immediately west of Sac county, and comprises twelve townships, or four hundred and thirty-two square miles. It is bounded on the north by Cherokee county, west by Woodbury, on the south by Crawford, and east by Sac county.

General Surface Features—Drainage. The county is mainly watered by Maple river, which flows southerly from the north boundary to a point about in the center of the county, and thence southwesterly, taking its exit in the southwest corner. It receives several small affluents within the borders of the county, the largest of which are Battle, Odebolt, and Elk creeks. The former drains a small area to the north and west of the Maple, and the two latter a more considerable tract to the eastward. Soldier river rises in the southeastern portion of the county, gathering its waters through innumerable "draws," and leaving the limits of the county before it has gained the dimensions of a good sized prairie brook. In the extreme northwest the Little Sioux and two or three small tributaries collect the drainage of the greater portion of two or three townships in that quarter. Besides those enumerated, there are many small water-courses, and innumerable lateral ravines intersect the uplands in every direction, completing one of the most remarkable and effective systems of surface drainage.

Surface Configuration. The county lies just within the

Missouri drainage. Its surface is more or less rolling and almost an uninterrupted prairie. In some places the land is indeed quite broken, rising into eminences of considerable elevation. But, in general, the uplands are not so rolling but that they may be readily cultivated, and in most instances they afford very desirable situations for agricultural purposes. The valleys are deeply cut into the superficial deposits in which their beds wholly rest. That of Maple river is one of the finest in the west. The stream winds through a level bottom-land, the average width of which is about half a mile; it is bordered by steep banks ten to fifteen feet high, and its rapid fall affords very good water-power. In places the bed of the river is composed of gravel, but for the greater part of its course in the county it flows over a bed of mud and quicksand. The bordering upland declivities gain the bottoms by graceful slopes, broken here and there by more abrupt descents, and now and then opening into equally beautiful valleys, which border the lower courses of many of the tributaries. These little valleys are often flanked by moderately elevated benches, which constitute an interesting feature in the scenery of this beautiful region. At the confluence of the Odebolt, one of these terrace-like formations crowds out into the valley of which it commands a charming view looking both up and down its course. Ida grove crowns the steep slopes upon the opposite side, and below clumps of soft-maple fringe the stream, giving to the valley the appearance of an extensive and well-ordered park.

In the vicinity of Ida grove, near the center of the county, the bottoms lie at about two hundred feet below the general upland level. To the eastward, in the divide between the Odeboldt and Elk creeks, there are isolated ridges which rise to a still greater height, and probably attain an elevation of fifteen hundred to sixteen hundred feet above the sea, being of even greater altitude than the watershed divide in Sac county, twelve or fifteen miles east. While the greater part of the southern portion of the county presents a broadly-rolling prairie, intersected by numerous drainage channels

whose sides are bordered by more or less gentle acclivities, to the northward the surface is more gently undulating, and finally merges into the level plains of Cherokee county a few miles beyond the northern limits of the county. The valleys of the smaller streams have a rapid ascent, and for the greater part along their courses they can hardly be said to possess any bottom-land, resembling in all respects rather deep, wide ravines. As we approach their sources, lateral ravines come down at more or less frequent intervals, and these again ramify in shallow depressions which draw the surface waters from every portion of the upland as effectually as though they had been laid out under the direction of an engineer.

With the exception of a few diminutive ponds in the south portion of the county, in which some of the branches of Soldier river rise, there are no wet lands in the county. The low bottoms in the valley of the Maple, are liable to annual overflow, but during the greater part of the year, these tracts are dry and afford the most luxuriant natural meadows.

Forests, etc. The scarcity of timber, doubtless, has had much to do in retarding the settlement of this fine region, but it is by no means the chief obstacle that has operated to prevent its becoming the home of a large and flourishing population. On the completion of the east and west railroads through this section of the State, large tracts of the best lands in the county have been thrown into market at reasonable price by the railroad corporations, so that the general settlement of the county dates back only two or three years, although a few settlements were established here ten or twelve years ago, or in the season of 1858 or 1859, that of Judge Morehead, at Ida Grove, being the first as it is also one of the finest estates in the West. The most considerable tract of timber in a single body, is that which lines the Maple and crowns the adjacent heights overlooking the valley on its west side, known as Ida Grove. It embraces a broken tract of ground containing about a quarter section, with the following varieties of trees: Soft-maple, bur-oak, red-elm,

hickory-elm, hickory, black-walnut, hackberry, box-elder, white-ash, etc. The observations on the encroachments of timber in the prairie regions of other counties are equally applicable to Ida county. In the outskirts of Ida grove, the hill-sides are in many places overgrown by a vigorous growth of young oaks, which in a few years will assume the proportions of forest trees. As soon as the prairie fires are checked by the improvements in various quarters, many of these young groves will increase and in a few years form forests of no inconsiderable extent.

Fruit trees also thrive well here. The young orchard on Judge Morehead's estate, including several of the hardier varieties of apple trees, and also a fine lot of grape-vines, presents as thrifty growth as anywhere to be found in the State. As yet, however, little attention has been given to the growing of fruit; but as the county becomes settled, there is no reason why horticulture should not claim, as it deserves, the earnest attention of our farmers which would not only supply one of the luxuries, but prove a source of material wealth.

The Soil throughout the county is mainly of Bluff origin. It consists of a buff-colored, exceedingly finely comminuted silicious earth, with an admixture in favorable situations, as in the beds of the drainage depressions and in the valleys of humus, which gives it its dark color, the same as in the loamy soils of eastern Iowa. Upon the higher points the soil contains comparatively little humus, for the reason that it is swept down by the rains as fast as it is accumulated by the decay of the herbage, and deposited in the beds of the ravines and in the valley bottoms, where it often forms a deposit of rich, black earth, several feet in thickness. In the sides of the deeper valleys there are gravelly plots, though of small extent. The soil in the bottoms consists of a dark mould, the sand being coarser than that in the upland soil, and probably was derived largely from the Drift Deposits, although it is mixed with the washings from the hill-sides to a very considerable extent, besides the sediments deposited

by the floods upon the lower bottoms, contiguous to the streams. There is not an acre of barren soil in the county, neither is there any portion of its surface but that may be made available for agricultural purposes in one way or other.

The uplands are covered by a thick growth of short herbage, affording the best of pasturage, and in the "draws" towards the heads of the ravines, we find a luxuriant growth of a variety of tall grass, called blue-joint, which is said to make hay not inferior to the cultivated varieties. In the valley of the Maple the finest meadow lands occur, the yield of hay per acre being enormous in many localities.

There are few springs that issue at the surface, and the probability is that wells will have to be sunk through the Bluff Deposit into the underlying gravel-bed of the Drift before a permanent supply of water can be obtained. The tenacious nature of the Bluff Deposit is such as to obviate the necessity of curbing, so that wells may be excavated to very considerable depths with comparatively little expense.

Upon one of the high ridges in the vicinity of Ida Grove, an extensive Indian encampment is still pointed out by the abundant remains of the carcasses of buffalo, elk, deer, and other game, which thickly cover the surface or lie half buried in the soil over an area of many acres. The site commands a magnificent view of the surrounding country, taking in miles of the beautiful valley at a glance. The course of the deeply worn trail is still visible, which is said to have been a great highway communicating with the extreme southeast and northwest portions of the territory now embraced in the State of Iowa.

Geology. No regularly stratified rock formations appear at the surface in the county. Its geological features are entirely moulded in the Post-tertiary formations, of which the latest deposit is by far most predominant.

The Drift is seen outcropping at various elevations in the valley-slopes on the Maple, and also appears over limited areas in the sides of some of the smaller valleys. It is

composed of gravel and boulders, held in yellow, sandy clays, quartzite and the usual varieties of gneiss and granitic boulders abounding. These deposits bear every evidence of having been extensively denuded, since their surface presents great unevenness, rising in places a hundred feet above the valley of the Maple, and then again sinking even below its level. In the immediate vicinity of Ida Grove, the gravel-bed makes its appearance in the bluffs upon the right side of the valley, and upon the opposite side the same deposit shows itself in broad undulating benches at the confluence of the valley of Odebolt creek. It also appears at many places lower down the valley, and in the uplands on both sides of the Maple its outcrop, however limited, may be readily detected by the prevalence of boulders and gravel at the surface. Ascending the valley of the Maple, the Drift gradually assumes a more important part in the surface geology, and but a few miles north of the northern boundary of the county, it forms almost the entire border slope of the uplands. It is impossible to estimate the thickness of these deposits in this region, since we have no knowledge of the depth they reach below their lowest exposures in the valleys. But it is well known that they locally attain one hundred feet, although this cannot be accepted as representing the mean thickness of the deposits. We see no indication of the glacial or blue clays, although they appear in the bluffs on the Missouri in the vicinity of Sioux City, fifty miles to the westward, and without doubt this deposit underlies the yellow gravelly clays in the valley of the Maple in this section.

The Bluff Formation overspreads the entire county, enveloping the uplands in a deep mantle of the peculiar silicious deposit of which it is composed. In the southern portion of the county it probably attains its greatest thickness, where it cannot be less than one hundred feet. On the eastern border of the county it forms quite high elevations, noticeable for their isolation and abruptness, and interesting as bearing unequivocal evidence of the great

thickness the formation once possessed compared with its condition at the present day. To the northward, the Bluff deposit gradually thins out as it approaches the great Drift plains in the watershed plateau, the northern limits of the formation being defined by a line passing in an east-south-east direction through the southern tier of townships in Cherokee county.

General Observations. The county being entirely destitute of rock-quarries, the material for building, where wood is not employed, must be derived from the superficial deposits or soil. It is believed that an abundance of earth suitable for the manufacture of a good quality of brick exists in all parts of the county. Wherever the Bluff Deposit has been exposed on steep slopes to the action of the frosts and its surface re-arranged by the washings of the rains, dissolving away the calcareous matter which it originally contained, it has been successfully employed in making brick in many sections, and there is no apparent reason why it may not be found to serve the same purpose here.

As an agricultural and grazing region it offers inducements equal to those of any region of the same extent in the State. The county already has the benefit of railroad communication within a few miles of its northern and southern limits, affording good facilities for marketing its produce, besides furnishing a cheap and constant supply of lumber for building purposes.

16. AUDUBON COUNTY.

Audubon county comprises twelve townships, or about four hundred and thirty-two square miles. The county is bounded on the north by Carroll, on the east by Guthrie, south by Cass county, and on the west by Shelby. The county lies almost wholly upon the Missouri slope, the eastern boundary conforming very nearly to the crest of the great divide separating the Mississippi and Missouri drainages.

General Surface Features. The East Nishnabotany, which

takes its rise just within Carroll county, flows southerly through the entire length of the county from north to south, receiving several small affluents, among which Bluegrass and David's creeks are the largest. Troublesome creek, also an affluent of the East Nishnabotany, waters the south-east township, and in the western portion of the county the Middle Nishnabotany and Indian creek have their sources.

The uplands between all the streams are beautiful tracts of rolling prairie, forming well-defined divides, from which the surface-waters are gathered by "draws" or slight depressions, and discharged into the ravines which descend to the valleys. The valleys are bordered by gentle acclivities, except where the drift gravel-bed crops out where the ascent is more abrupt till reaching the superimposed Bluff Deposit. The bottoms are gently sloping to the margins of the streams, which are deeply eroded into the fine, black soil, and their beds often paved with gravel. The valley of the East Nishnabotany is one of the most beautiful sections in this district. The stream meanders through a broad, fertile, bottom-plain which is interspersed with groves and clumps of trees with here and there thrifty farms, affording a landscape of quiet, rural beauty, such as one does not often meet with in the sparsely settled districts of western Iowa. At Exira, the stream is between one hundred and fifty and two hundred feet below the general level of the watershed. The divides to the westward are considerably higher than the watershed, and the highest elevations in the northern part of the county are not far from fourteen hundred feet above tide-water.

From the summit of the great divide, in the north part of the county, a magnificent panorama of the surrounding country is commanded. To the eastward, overlooking the country drained by the tributaries of the Des Moines, in the foreground, the surface appears broken and the horizon is bounded by a perfectly level plain. In the west, southwest, and south, the eye scans the distant horizon which is bounded by a lofty prairie barrier, enveloped in the uncertain shimmering haze of a summer's day, and seeming like a vast rim

bounding the farther outline of an immense shallow basin, whose middle portion is occupied by gracefully, undulating prairie swells, which rise and fall, one beyond another, until distance blends the whole into lines of light and shadow. An ordinary prairie landscape is, indeed, monotonous enough ; but when one commands a view, like the above, outstretched over a radius of thirty or forty miles, embracing a region, every acre of which is the finest arable land in the world, for the first time we gain an intelligible impression and a just appreciation of the grandeur of these undulating treeless plains.

The county is estimated to possess about sixteen hundred acres of forest land. Hamlin's grove on the southern border, and the grove near Exira, are the largest bodies of timber in the county. Along the larger streams, narrow belts of young timber occur at intervals, and upon the upland slopes, considerable areas are occupied by stunted growths of burr and red oaks. North of Exira, one of these "oak-openings" forms a small forest, interspersed with a dense under-growth, consisting of butternut, hazel, sumach, and the wild plum.

The soil is mainly composed of the light colored, fine material of the Bluff formation. In the slopes, there are places where more or less gravel is mixed with the soil, and in the valleys is found a deep, black accumulation which is principally composed of the washings from the adjacent acclivities.

Geology. The Post-tertiary formations everywhere occupy the surface, burying completely from view the older geological formations. The Drift Deposits are but imperfectly, known, appearing only here and there at infrequent intervals from beneath the more recent bluff formation, and natural sections are rarely met with. Near Exira, however, in a ravine on David's creek, a vertical exposure of from thirty to forty feet of Drift may be seen, which is made up of yellow, sandy clays with gravel and boulders. The gravel bed is found outcropping at much higher elevations in the upland slopes, where they produce an abrupt descent

which always distinguishes the presence of these deposits wherever they gain the surface. Boulders of red quartzite are met with quite commonly, though the gneissose and granitic materials largely predominate upon these hill-side exposures. The Drift, however, is so deeply covered by the Bluff Deposit that it has little influence in modifying the soil even in the valleys, which is almost wholly derived from the Bluff Deposit and uniformly spread over the surface.

The Bluff Deposit attains in the divides, in the western portion of the county, a thickness probably equal to that of the underlying Drift, or not less than seventy-five feet. It here presents, apparently, the same uniformity in composition as noticed elsewhere, even at the typical localities in the Missouri valley—a light colored, very finely comminuted, silicious deposit containing more or less calcareous matter, often in the form of small concretions and a very small percentage of clay ; and here, as elsewhere, it forms a very excellent soil.

General Observations. *Building Material* is very scarce in Audubon county ; there is no stone except the boulders in the Drift, and they are not abundant. Brick has been manufactured at Exira, the material being obtained from the soil in the valleys. But whether it is owing to the mixture not being properly proportioned, or whether it is due to the unfitness of the earth for this purpose, the brick are poor in quality, crumbling in pieces from exposure. The supply of native lumber will soon be inadequate to meet the demand caused by the rapid settlement of the county ; and then the supply must be drawn from the great pine regions of the north, which are made accessible by two main lines of railway which pass within a short distance of both the north and south boundaries of the county.

The soil could not be more fertile, except so rendered by artificial means. The cereals and corn are particularly well adapted for the peculiar soil of this region, whose fineness and depth affords a very thorough under drainage, and at the same time it is retentive of sufficient moisture, even in unusually dry seasons, to ensure at least a medium crop.

17. CRAWFORD COUNTY.

Crawford county is bounded on the north by Sac and Ida counties, on the east by Carroll, west by Monona, and south by Shelby county. It comprises sixteen townships, having an area of five hundred and seventy-six square miles.

General Surface Features. The Boyer river crosses the county diagonally from the northeast to the southwest corner, and, with its affluents, drains the more considerable portion of the county. The East Boyer has its sources in the great divide on the western borders of Carroll county, and flowing westerly, it joins the main stream near the centre of the county at Denison. The head waters of the West Nishnabotany rise in the southeastern part of the county; and the northwestern townships are drained by the numerous ravines and rivulets tributary to the Soldier river. There is hardly a county in the State that possesses as complete a system of natural drainage as Crawford. The smaller tributaries are numerous and reach their ravine-like arms in every direction; their beds are muddy or gravelly, and bordered by steep earth and grass-covered banks. The larger streams always furnish an abundant supply of water, and even in the driest seasons the smaller water-courses possess little pools in their beds at frequent intervals.

The surface configuration is rolling. The divides separating the streams are bulky masses of earth which sweep down into the valleys over beautiful declivities, from the undulating plain above. In the region of the head waters of the streams, the surface is more rolling than it is in the main divide ridges; but there is no section which can be strictly called broken. The soil is almost uniformly the light-colored, fine silicious material of Bluff origin, but in the valleys, in places, it is largely intermixed with sand, and sometimes gravelly plots are met with, though rarely. In the smaller and narrower valleys and ravines often extensive accumulations of black soil have been made, which is probably due to the washings of the rains upon the adjacent

slopes which bear evident signs of having been denuded in this manner of their coating of dark humus.

Forest growths are very meagre, and almost wholly restricted to the banks of the larger streams and adjacent valley-slopes. There can be hardly a more pleasing rural landscape than that afforded by the valleys of the Boyer and East Boyer, as viewed from the upland ridges at most any point along their course, overlooking miles of their park-like courses, embellished with clumps of trees, and farms and villages, which are rapidly springing into existence throughout this beautiful region. On Judge Bassett's estate near Denison, a fine grove of thrifty young trees forms a very attractive feature in that vicinity. A few miles above Denison, on the Boyer, another small grove is rapidly spreading over the prairie slopes. At and below Denison, the stream is lined with a narrow belt of trees. In other sections of the county considerable tracts are grown up with a dense low growth of burr-oaks. But in the sparsely settled prairies the fires have unobstructed sway in early spring and fall, destroying the majority of the young shoots of each season's growth, or so retarding their naturally vigorous growth, as to produce a scraggy, dwarfed trunk, which bears but mocking semblance to the noble tree whose early existence was less harassed.

Geology. In the bottoms, and low in the sides of the valleys, the gravel deposit of the Drift is sometimes exposed; in the latter situations forming low rounded outliers, and obscurely defined benches protruding from beneath the heavy deposit of Bluff material. Where these deposits come in contact the gravel is not unfrequently cemented by lime and ferruginous infiltrations, forming concrete of considerable extent and durability. This stratum being more or less impervious, gives origin to numerous springs which issue from the hill-sides in many localities, and which, in this instance, are not due to the presence of the impervious glacial clays, as is almost always the case in the Drift region in the eastern portion of the State. An exposure of the concrete

bed occurs in the banks of a rivulet on Judge Bassett's farm, and also half a mile east of Denison, on a small branch of the East Boyer, where the bed has the appearance of a highly ferruginous quartzose sandstone; it, however, contains but a small percentage of iron, barely enough to cement the grains of coarse sand sufficiently not to crumble in pieces. Judge Bassett has quarried a considerable quantity of the concrete on his place for underpinnings, for which purpose, in fault of a better material, it answers very well.

The Bluff Formation constitutes the bulk of the superficial deposits in the county, and presents the same peculiarities of composition which characterize the formation at its typical exposures in the counties on the Missouri river. However, in some of its surface aspects it offers a marked contrast; but it is a contrast which becomes less and less conspicuous as we approach the grand facades bordering the Missouri bottoms throughout their entire extent in Iowa, and into which the gentle slopes of the inland region so gradually merge, that we are not taken by surprise on gaining our first view of the picturesque ranges of bluffs, which constitute so peculiar and interesting a feature in the scenery of the Missouri valley.

Of the existence of rocks of older age than the Post-tertiary in the county, we have no positive evidence. The Cretaceous, doubtless, once occurred in this region; but as yet its presence is indicated only by the fragments found associated with the erratic material of the Drift in various parts of the county. On Paradise creek and at Denison, the Drift Deposit has afforded fragments of gray silicious limestone containing ichthyic remains characteristic of well known horizons in the Lower Cretaceous in the vicinity of Sioux city, in Woodbury county. Of the coal-measure series, even if it does underlie the area embraced in Crawford county, the productive or Lower formation probably lies at so great a depth beneath the surface as to render its development for the present impracticable.

General Observations. In the foregoing description of the

geological features of Crawford county, it has been shown that no extensive formations of rock suitable for building purposes occur in the county. At Denison, a fair quality of brick is made from the soil found in the valley. Also, the modified Drift gravel affords an abundant supply of material for the manufacture of pressed concrete blocks, which has been undertaken by a company at Denison, but with what success attending the enterprise we are not informed. It is not improbable, however, that the concrete blocks will eventually become an important building material when experience shall have perfected the process of manufacture, which, at present seems unsatisfactory.

In a region where fuel is so scarce, too great provision for the future necessities can not be made. The early planting of groves will obviate great needless expense, besides proving a source of profit to those who turn some attention towards anticipating the future demand for fuel by a rapidly increasing population. The county is well adapted for both grain and stock raising. Its prairies afford a fine range for herds, and the streams an unfailing supply of water. The Chicago and Northwestern Railway passes down the valley of the East Boyer, and with the completion of this line, this fine section dates the commencement of its well deserved though long deferred progress and prosperity.

18. SHELBY COUNTY.

Shelby county lies immediately west of Audubon, and is bounded north by Crawford, on the west by Harrison, and south by Cass and Pottawattamie counties. It comprises sixteen townships, or an area of five hundred and seventy-six square miles.

General Surface Features. The county is watered by the West Nishnabotany, which flows south through the middle of the county, Whitted's creek, Middle Nishnabotany, and Indian creek, all tributaries of the former stream on its eastern bank. The west half of the county is principally

drained by Silver, Mosquito, Pigeon, and Picayune creeks, affluents of the Boyer and Missouri rivers.

The streams are deeply excavated into the superficial deposits from one hundred to two hundred feet, and are bordered by rather steep slopes, with gently sloping bottom-lands varying from a quarter of a mile to one mile and upwards in breadth. The country lying between the water-courses is rolling, and where the streams closely approach one another the surface is often broken and intersected by deep, short ravines. The divides are evenly rounded on their summits and channeled in every direction by "draws" or slight drainage depressions. The streams have cut their channels ten to fifteen feet into the black soil which fills the valleys, and are bordered by steep, muddy banks; their beds are composed of quick-sand and mud, and rarely of gravel.

The valley of the West Nishnabotany is a beautiful tract of sloping bottom-land of an average width of about a mile, and the banks of the stream are lined by narrow belts or clumps of trees. The valley of Mosquito creek affords another fine tract of bottom-land, but there is scarcely a shrub to be seen along its banks throughout its course in this county. Silver creek rises in the high undulating divide between the former stream and the West Nishnabotany, its valley is less deeply excavated, and its bottom-lands are wet and miry. The Middle Nishnabotany and Whitted's creek both possess fine bottom slopes, bordered by gentle acclivities. Little clusters of trees line their banks at intervals; and at Cuppy's grove, on the former stream, a fine body of young forests occurs. On Mill creek, in the northwest corner of the county, there is quite an extensive forest, containing about eighteen hundred acres. It is known as Galland's grove, and is the largest body of timber in this region. The following is a list of the common trees found in Galland's grove, which embraces the varieties commonly found throughout this section of the State: burr and red oak, red and common elm, butternut, hackberry, black walnut, ash, linden, iron-wood, coffee-bean;

also sumach, thorn apple, blackberry, gooseberry, grape, and other undergrowth. It is a noticeable fact that cottonwood trees are rarely met with in the native groves of the inland districts on the Missouri slope, nor do these trees thrive any better when transplanted than any of the other varieties of forest trees. The encroachment of the timber upon the prairie under favorable circumstances—*i. e.*, when the prairie-fires are checked—is almost incredible. Where we observe to-day a little outlying thicket of hazel and sumach—the pioneers of forest increase—a few years hence, unless arrested by the devastating fires, a grove of thrifty saplings will have sprung up, and this process is repeated indefinitely, until the beautiful prairie slopes are converted into forest clad ridges and sombre thicket dells, as wild and uninviting to the agriculturist as may anywhere be found. Indeed, the apparent scarcity of forests in these counties will be no real drawback to their rapid settlement—not near as great as would be the case were our prairies clothed with a heavy growth of trees—now that building lumber is as easily obtained as it is in any of the counties of central Iowa. And more than all, these vast meadows of unbounded fertility hold out inducements to the settler such as no forest clad region can boast.

Geology. The Post-tertiary deposits deeply cover all parts of the county, completely hiding from view the older geological formations which underlie the region. As in the counties previously described, these deposits include the Drift and the Bluff. The modified or gravel deposits of the Drift is well displayed on Mill creek, in Galland's grove, where it is seen resting upon the blue, glacial clays, and is overlaid by the peculiar yellow Bluff Deposit. The sands and gravel are arranged in the most perfect order, presenting all varieties of stratification commonly observed in connection with these deposits, and rest upon a thin stratum of hard-pan, such as is not unfrequently found in connection with the blue clays, although it by no means forms a persistent feature in the stratigraphy of these deposits. The gravel and boulder

deposits crop out in the sides of the valleys at a much less elevation than in Audubon county; at the same time, the Bluff Deposit is proportionally thicker than it is in the counties to the eastward. In the northern portion of the county, the Drift Deposits appear in one of the highest ridges in this region, recalling the great drift ridges of Sac and the counties along the eastern margin of the watershed where the accumulations of coarse materials form the most prominent feature in the surface geology. The outlier on the northern border of Shelby county, is merely a remnant of a formation that once occupied the entire region now embraced in the Missouri basin. The ridge is covered with boulders of granite, gneiss, quartzite and limestone, presenting a striking contrast to the smooth, stoneless surfaces of the adjacent ridges composed of the fine material of the Bluff Deposit.

The county is doubtless underlaid by the Upper coal-measures. These strata are known to exist in the counties to the south and west, but here the formation is concealed beneath an aggregate thickness of not less than two hundred and fifty feet of Post-tertiary deposits. The soft sandstone and clays of the Lower Cretaceous formations were doubtless extensively denuded during the glacial epoch, leaving only isolated patches here and there to mark, as it were, their former extent; but as yet not a vestige of these beds has been discovered within the limits of Shelby county.

General Observations. Building material is exceedingly scarce in the county. The surface deposit in the valleys may be found to answer for the manufacture of brick, but as yet no practical experiments of the kind have come to our knowledge; however, we cannot doubt but that the same success will be attained here as elsewhere in this section. The soil everywhere is of the most productive nature. The steeper slopes in the more broken sections will always afford excellent pasturage, or they may be easily clothed with groves. In the valleys the finest meadow lands are found, and the uplands afford beautiful locations for farms.

19. HARRISON COUNTY.

This county is situated on the western border of the State, the Missouri river forming its western boundary; it is bounded on the south by Pottawattamie county, on the east by Shelby, and north by Monona and Crawford counties.

General Surface Features. The county presents a greater variety of surface configuration than is found in the inland counties to the eastward. Many of the streams which water the counties previously described, gain the Missouri bottoms within the limits of Harrison county; and where they issue from the uplands upon the bottoms, the bluffs assume those picturesque and striking shapes which are so peculiar to the region immediately embraced in the Missouri valley. The county is watered by several small streams which flow diagonally across its territory from the northeast to the southwest. The principal water-courses are the Boyer, Willow creek, Soldier river, and the Little Sioux; and in the southeastern townships, Pigeon and Mosquito creeks. The valley of the Boyer is a fine tract of alluvial land from half a mile to one and a half miles wide, bounded upon either hand by the gentle descents of the upland, until its near approach to the Missouri bottoms, where the valley-sides are much more abrupt. The Little Sioux flows mainly through the bottoms on reaching Harrison county. Its debouche from the uplands is marked by the most singular groups of bluffs, whose sides are deeply channeled by short ravines, and atop weathered into conical peaks flanked by sharp crested, spur-like ridges.

Soldier river waters one of the most beautiful valleys on the Missouri slope. The north or west side of the valley is bounded by ranges of bluffs unrivaled in the variety of picturesque scenery by any similar region in the Missouri valley. The bottom lands are level, or but gently sloping from the foot of the bluffs towards the river, and what is more striking and interesting, well-defined terraces occupy a large part of the valley which afford beautiful rural situations. The

valleys of Pigeon and Mosquito creeks, are margined by high, sloping uplands, and their beds occupied by tracts of rich alluvial lands. The Missouri bottoms vary from four to eight miles in width in this county, forming a nearly level plain which is traversed by low benches or undulations more or less parallel to the Missouri river and to one another. The intermediate low grounds afford natural drainage channels, which receive and confine within bounds much of the surplus waters of the Missouri in the season of the freshets, which would otherwise flood extensive tracts of the best lands for agricultural purposes in the West.

The Soil in the uplands consists of the light colored deposits of the Bluff formation, which differs from that of the bottoms mainly in the more finely comminuted condition of the silicious materials of which it is largely, composed and in having a less amount of vegetable matter or humus. Indeed, the soil of the Missouri bottoms differs from that of the uplands only in degree, as both were and are derived from the same sources; but in the later deposits of the Missouri river the finer particles are mostly swept along with the ceaseless flood, and only the coarser materials are deposited during the periodic overflows along this middle course of the great river.

Forest growths are limited in extent, and their distribution is governed by circumstances favorable to their preservation. Hence, in the deep shaded ravines that crowd up into the bluffs bordering the Missouri bottoms, and along the smaller streams which are confined to narrow valleys, hemmed in by steep bluff ascents, the most vigorous growths of native forests are found. But, as observation has repeatedly shown in all parts of the State, forests are not necessarily restricted to the valleys and moister localities, and thrive as well in one location as another, when the devastations of the prairie fires are checked for a period of sufficient duration to allow the young trees a few years of unretarded growth. Whole tracts of hundreds of acres of prairie have been overgrown with thrifty groves within the brief memory of the early settlements,

which does not extend back a score of years. These tracts of young forests add a pleasing feature to the landscape in these beautiful undulating upland divides, as that near Magnolia, and Harris' grove in the divide between the Boyer and Pigeon creek, south of Logan, attests. In the valleys of the Soldier and Little Sioux small groves are met with, and a belt of fine forests lines the banks of the Missouri throughout its course in the county.

Geology. In Harrison county the Post-tertiary deposits exhibit their usual characteristics, and besides these we have limited exposures of the Upper coal-measures which appear in the valley of the Boyer.

Post-tertiary. The Drift and Bluff Deposits are both well developed in Harrison county, where the latter attains near its maximum thickness.

The *Drift Deposits* comprise both the glacial clays and the modified or gravel-beds. We seldom find both these beds well developed at a single locality, and more often they are so attenuated by denudation as to present a striking contrast to the condition they present in central Iowa. The Glacial Deposit is seldom exposed more than a few feet, and it is doubtless comparatively thin throughout this section. It fills depressions in the subjacent formations, and in these situations it has been subjected to less extensive erosion than it has on the higher points, where indeed this deposit has been generally entirely swept away. In such places the gravel bed attains, or retains, a thickness of several feet—perhaps at some localities as great as thirty feet. At other places, however, even the gravel deposit has been wholly denuded, or is represented by a thin sheet of pebbles and sand which have been converted into a quite durable concrete. Springs are of frequent occurrence along the outcrop of the gravel and blue-clay deposits, and they always give a reliable horizon, showing the inequalities of the denuded drift surfaces, and also the line of demarcation between these deposits and the Bluff formation.

In the south side of the Boyer on the southern borders of

the county, the Drift Deposits rise in the base of the bluffs to an elevation of thirty feet above the bottoms. In the opposite side of the valley, in the vicinity of Missouri Valley, the Bluff Deposit constitutes the entire height of the bluffs, which are here two hundred feet in height above the Missouri bottoms. In the valley of the Little Sioux, in the northern portion of the county, similar exposures of the Drift are met with. Three miles above the village of Little Sioux, on Mr. Thomas Neeley's place, a tufaceous deposit is in process of formation at the base of the Bluff Deposit. It is underlaid by a gravel-bed which in places has been incorporated in the calcareous formation, forming a very durable concrete layer. The tufaceous deposit contains the shells of *Helices*, (*Helix* ———), and beautifully preserved impressions of the leaves of trees growing upon the spot. The rock is very porous and from two to three feet thick; it seems to be a local formation of limited extent, and probably does not extend far into the hill, or more than a very few feet. A very similar deposit has been found on Mr. David Vanderhoof's farm in Harris Grove, and the concrete bed is exposed at numerous localities in various parts of the county, as in the base of the bluffs on Smith's lake, and elsewhere.

The Bluff Formation, as has been stated already, constitutes the bulk of the rounded divides between the streams, and in the bluffs on the Missouri bottoms it reaches a thickness upwards of two hundred and fifty feet. Owing to the tenaceous nature of the Bluff material, landslides are of very infrequent occurrence; and it is also due to the same condition of this deposit, that by the slow process of weathering by the action of atmospheric agencies, and the little rills which issue from the gravel-bed, these bluffs assume the varied and picturesque outlines which form so striking a peculiarity in the topography of the upland border region in this part of the State.

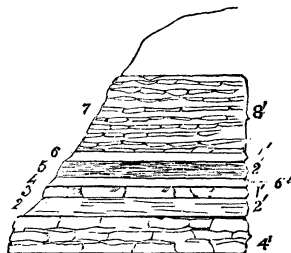
The most interesting subject for study presented by this formation in this county, are the terraces which occupy the valley of Soldier river, in township 81, range 44. The lower

benches are from thirty to fifty feet in height, and are found on both sides of the stream, which has at different times eroded new channels—the old ones existing to-day as “old river beds,” or low meadow lands of surpassing fertility. The main terraces are confined to the west side of the valley, and, compared with similar phenomena observed elsewhere in the State, they are truly colossal. The benches of different elevations are often separated from one another by deep, narrow ravines, or shallow depressions, which are more or less exaggerated expressions of identical features associated with these formations in the Drift region from which they differ, only in the nature of the material of which they are composed, and possibly in the date of their formation. They have a very gentle, regular inclination from the uplands toward their valley faces which are abruptly terminated by the steep descents peculiar to terrace formations. The intermediate terraces are quite regular in conformation and vary from sixty to one hundred feet in height. The high terraces are somewhat less distinctly defined, though, varied from the opposite side of the valley, they present no appreciable difference from the lower benches, their upper surface forming gently undulating or nearly level plains above one hundred and fifty feet above the bottoms, offering a prominent contrast to the very irregularly weathered surface in the upland heights between the Soldier and the Little Sioux, which lift their furrowed crests to the height of two hundred to three hundred feet above the valley.

Coal-Measures. The Upper coal formation presents limited outcrops of limestone at two or three localities on the Boyer river, which are the most northerly exposures of this formation in the State. It is a fact of some interest that the appearance of Upper coal strata in Harrison county, occurs on a line but little north of due west of the northern border outcrop of the formation in Guthrie and Dallas counties; and also, in the intermediate ground in Cass and Adair counties, horizons have been described by Dr. White, which bear a remarkably close resemblance to the beds seen on the

Boyer in this county. From these meagre data, it would appear that the northern border trend of the upper coal-formation, on leaving the Raccoon region at its northeastern angle, pursues a west-northwest direction to the Missouri river, where it disappears beneath the vast accumulation of strata pertaining to the Mesozoic and Cenozoic in the great plains of the State of Nebraska.

FIG. 86.



In the vicinity of Logan, a limited outcrop of Upper coal strata appears in the banks of the Boyer, just below Reel's mills, in section 19, township 79, range 42, presenting the following section:

Section near Logan, Boyer river.

No. 7. Irregular bedded, shaly, impure limestone, with clay partings, exposed 8 feet. Contains *Spirifer cameratus*, *Spiriferina Kentuckensis*, *Athyris subtilita*, *Productus longispinus*, *P. costatus*, *Hemipronites crassus* (?), Crinoid stems, etc.

No. 6. Yellow, marly clay, 1 foot.

No. 5. Black, carbonaceous shales $1\frac{1}{2}$ to 2 feet.

No. 4. Yellow clay, irregular, 6 to 12 inches.

No. 3. Blue, impure limestone, 1 foot.

No. 2. Yellow, indurated clay, 2 feet. With *Athyris subtilita*, *Spirifer cameratus*, etc.

No. 1. Compact, light gray limestone, with clay partings, exposed to bed of river, 3 to 4 feet.

The same limestone outcrops in the valley-side half a mile below Logan, on Mr. S. L. Case's farm, in section 24, township 79, range 43. The lower bed of limestone furnishes a tolerable building stone, for which purpose it was quarried and used in the court-house in Council Bluffs. Mr. S. I. King informs me that a bed of excellent limestone, upwards of twelve feet in thickness, has been opened in the left bank of the Boyer, at Davis and Donmyer's mill, two miles below Woodbine, or six miles above Logan, where considerable quantities of building stone have been quarried. This

exposure was not known at the time this section was visited, therefore, we can give no details regarding the character of the outcrop, although it belongs, without doubt, to the same set of strata as those above described. At any of these exposures, the rock may be easily obtained by throwing off a few feet of the superincumbent earth and debris, and, considering the scarcity of building stone in the county, these quarries will eventually become important resources for building material.

Economical Geology. Although the Upper coal-measures outcrop in the county, no deposits of mineral fuel are here found associated with these strata, which, it is believed, belong to horizons high in that formation. It is not improbable, however, that coal may be found by boring, but the productive measures, doubtless, lie at a depth of several hundred feet, and owing to the accessibility of the coal-field on the Des Moines river, it will be long before the demand for coal in this section will justify the risks and great expenditures incidental to shaft mining.

Building stone may be abundantly obtained at the quarries near Logan, and below Woodbine; and the soil will afford unlimited supplies of material suitable for the manufacture of brick. The growth of artificial groves should early engage the earnest attention of the people, for every farmer who possesses an eighty acre lot can grow his own fuel as he does his grain. For fencing and building purposes, a much better quality of lumber can now be obtained from the pine region of the Upper Mississippi than that afforded by the native forests. Should hedging prove successful, it will soon supersede all other kinds of fencing. The Chicago and Northwestern Railway passes down the valley of the Boyer, and the Sioux City and Pacific Railroad traverses the bottoms in the western portion of the county, connecting with the former road at Missouri Valley, and forming a link in the great railway line through the valley of the Missouri, connecting at St. Louis with the Upper Missouri country. As an agricultural region, the county is one of the best in the State;

the bottoms afford excellent meadow and arable lands, and the uplands afford the finest situations for farms and extensive grazing ranges, and the streams furnish an abundant supply of water for stock.

20. MONONA COUNTY

Monona county contains an area of about six hundred and twenty-five square miles. It lies north of Harrison county, which forms its southern boundary, and is bounded on the east by Crawford county, north by Woodbury county, and on the west by the Missouri river.

General Surface Features. About one-third of the area of the county is embraced in the Missouri bottoms, which gradually widen from seven miles on the south border, to seventeen miles in width on the northern line of the county. The ascent of the bottoms northward, is somewhat more rapid than that of the Missouri river, hence there is but a comparatively small portion of the bottom-lands subject to overflow from the Missouri in high water. In the midst of this great alluvial plain, the thriving village of Onawa is situated, surrounded by a region of unsurpassed agricultural resources.

The eastern portion of the county presents a rolling prairie surface, which is well watered on Willow creek, Soldier and Maple rivers, and their numerous affluents. The Little Sioux flows southerly through the forty-fourth range of townships, receiving the West Fork on its right bank about the middle of the county. The uplands abruptly abut on the bottoms along the east side of the Little Sioux, and present the varied and peculiar features of erosion characteristic of bluffs along the Missouri bottoms throughout their extent in the State. The bluff heights are quite uniform in elevation, the highest points reaching not less than three hundred feet above the Missouri river, or about thirteen hundred feet above the sea. In the immediate vicinity of the bluffs, the uplands are very broken, and cut up with narrow, wooded ravines. The

valleys of the smaller streams a few miles inland, are bordered by more gentle acclivities which ascend from the sloping bottoms to the rolling divides intervening between the watercourses. The valleys of the Maple and Soldier rivers for the greater part of their course in this county, are occupied by fine tracts of bottom-land from half a mile to one and a half miles in width. The streams themselves are margined by grassy banks, and their beds are miry or filled with quicksands.

The soil in the valleys is usually a deep, black mould or a fine loam. In the Missouri bottoms, low sand-ridges are not unfrequently met with, which are the remains of bars formed by the currents when the river occupied the whole width of the valley from bluff to bluff on either side. It would seem that the bottom deposits are quite variable in the character of their component materials, though the fine dark loam constitutes by far the greater proportion of surface soil. This is underlaid by sand and gravel, and sometimes a deposit of silt and clay containing large quantities of partially decayed wood and other vegetable matter. These deposits are frequently met with in sinking wells in various parts of the bottoms. The uplands are covered by a coating of brown, humus-charged soil, with a subsoil of the light colored Bluff Deposit.

The principal bodies of timber are found upon the bottoms bordering the banks of the Missouri. There are other more or less considerable groves on the Little Sioux, and many of the deep ravines, upon its left bank, are densely shaded with luxuriant forest growths. Wells of excellent water are easily obtained in the bottoms at depths varying from ten to twenty feet; but the prevailing custom of using cottonwood plank for curbing, renders the water exceedingly unpalatable. In the uplands, wells are often dug to the depth of one hundred feet, through the Bluff Deposit, the tenaceous nature of which obviates the necessity of employing curbing of any description. Springs issue from the base of the bluffs at frequent intervals, and the streams afford a plentiful supply of water

for stock. They also, might afford water power were it less difficult to improve these sites, owing to the yielding nature of the banks which are easily washed away by the floods wherever the waters are dammed. The bottoms furnish several varieties of native grasses which make a good quality of hay; the uplands afford a boundless grazing range.

Geology. The geological formations thus far known to occur at the surface in Monona county belong to the Post-tertiary period. The lower formations of the Cretaceous period doubtless once overspread the entire area of Monona and the adjacent counties, and may indeed still underlie a considerable portion of its area. At Blackburn's, below the mouth of the west fork of the Little Sioux, in digging a well, red clays were found at a depth of about forty-five feet below the bottoms, which possibly belong to this series of rocks. Of the earlier geological deposits not a vestige is exposed to view within the limits of the county.

Post-tertiary. The *Drift Deposits* outcrop at irregular elevations in the base of the bluffs on the Missouri bottoms, gradually increasing in elevation from the south to the northward where they reach the height of one hundred feet above the Missouri. These deposits here include the blue clay and "hard-pan" layers, and above these the yellow, sandy clays and gravel-bed of modified drift material. In places, the lower or unmodified clays rise high above the bottom level, giving origin to springs which issue from the bluffs at numerous places. The line of the outcrop is very irregular, and the overlying gravel-beds seem to be quite as variable in thickness—in places attaining a thickness of not less than fifty feet, and at other localities wanting altogether. These deposits are found at a level seventy-five feet above the bottoms in the bluffs just below the mouth of Maple river. At Mr. Baggs', in section 27, township 83, range 44, a spring of large volume issues from the base of the gravel-bed. In the bluffs, east of Woodward's, on the line between townships 85, of ranges 44 and 45, the same

deposits are seen at an elevation of about one hundred feet above the valley, forming rounded benches whose surfaces are strewn with boulders and gravel, and upon which a thickness of one hundred or more feet of Bluff Deposit rests. Here, as elsewhere, the presence of the glacial clays is indicated by the prevalence of springs which gain the surface at the line of demarcation between these beds and the gravel deposit. Higher up the valley, in the neighborhood of the confluence of the West Fork and Little Sioux, the Drift is found as high up the valley-sides as one hundred and twenty-five to one hundred and fifty feet above the stream. The inequalities in the surface of these deposits are attributable to the effects of extensive erosion subsequent to their deposition and which has greatly reduced their original extent and entirely remodeled their original surface conformation.

The Bluff Formation still constitutes an important member of the superficial deposits in the uplands. But it is very evident that this deposit is gradually diminishing in thickness as we ascend the valley of the Missouri, and though it is found to be between two and three hundred feet in Monona county, it does not here present the same uniformity in thickness observed in the counties to the southward. Indeed, in this region its greatest thickness is found in deep depressions produced by the erosion of the underlying Drift Deposits, which are gradually rising from the bottom-level, causing a corresponding diminution in the general thickness of the Bluff Deposit to the northward. Eight or ten miles below Onawa, in the neighborhood of Mr. Nickerson's, township 82, range 44, this deposit composes nearly the entire height of the bluffs, which are from two hundred and seventy-five to three hundred feet in height. In the vicinity of the mouth of Maple river, four miles above Nickerson's, it is not above one hundred and sixty feet in thickness; and above the confluence of the West fork of Little Sioux, it is still further diminished.

Near the confluence of Maple river, a beautiful terrace plateau, composed of Bluff material, occupies the valley

between the former stream and Beaver creek, upon which the village of Bellevue is situated. This bench is about one hundred and fifteen feet above the level of Maple river, and is similar in all respects to the terrace formations observed in the valley of the Soldier, in Harrison county. In digging wells, the blue clays of the Drift were encountered at a depth of one hundred to one hundred and ten feet below the surface of the terrace plateau. In both sides of the valley these deposits rise to the height of seventy-five and one hundred and twenty-five feet above the present level of the streams, which shows beyond a doubt that they were extensively denuded prior to the deposition of the Bluff Deposit, and it seems highly probable that the valley of the Maple had an existence prior to the sub-epoch of the Bluff formation.

General Observations. No quarries of stone are found in the county. The materials for making brick are abundantly supplied by the surface deposits. The local supply of fuel is entirely dependent on the forests, which, though of comparatively limited extent, are amply adequate for the present wants. But, in view of the rapid settlement this region invites, unless the future demand is anticipated by the growing of artificial groves, the lack of a convenient and cheap fuel will eventually be more apparent than it is at the present time.

21. WOODBURY COUNTY.

This county is situated on the western border of the State, and embraces a superficial area of about eight hundred and sixty square miles. It is bounded on the south by Monona, on the east by Ida, and on the north by Plymouth and Cherokee counties; its western boundary is formed by the Missouri river with the exception of a few miles bordering upon the Big Sioux river, in the northwestern portion of the county.

General Surface Features—Drainage. The eastern and middle portion of the county is watered by the Little Sioux

river and the West Fork. Maple river traverses the southeastern township, where it is bordered by fine bottomlands and gentle acclivities. The western portion is watered by several small streams, which, on reaching the Missouri bottoms, lose their channels in the low marshy tract that skirts the foot of the bluffs and drains into the West Fork of the Little Sioux. Floyd river and Perry creek, in the western portion of the county gain the Missouri in the immediate vicinity of Sioux City.

Surface Configuration. This county, like all the Missouri river counties, may be divided into two sections, each possessing its own physical peculiarities as presented by broad bottom plain and undulating uplands. The Missouri bottoms have a width of fifteen miles on the southern border of the county, embracing an area of one hundred and fifty square miles. Very little of this extensive tract is occupied by marshes and but a comparatively small portion is subject to inundation during the periodic freshets of the Missouri river. Long, narrow lakelets, encircled in many instances by groves of cotton wood and elm are not unfrequent and are generally supposed to be abandoned channels of the Missouri.

The uplands rise less abruptly from the bottoms than is the case in the counties to the southward, though the higher points still reach an elevation above the river of from two hundred to three hundred feet. To the northward, the bluffs gradually approach the Missouri, narrowing the intervening bottoms, and finally abut immediately upon the river at Floyd's bluff, three miles below Sioux City. Above this point, at the mouth of Floyd river, the bottoms again crowd inland forming the beautiful bluff environed plain upon which Sioux City is located. The range of bluffs along the Missouri bottoms throughout the county form a striking feature in the scenery; prominent headlands and sharp crested ridges surmounted by conical heights push boldly out into the valley at more or less regular intervals of a few miles, between which points the bluffs retreat inland giving rise to amphitheatres, of which that between Woodbury and

Thompson's bluff is an interesting and characteristic example. In the interior the uplands are rolling, descending into the valleys by graceful declivities. The watercourses are confined within steep, grassy banks, and are margined by sloping bottom-lands half a mile to two miles in width.

The Soil of the uplands consists of a mixture of vegetable matter with the fine, yellow, silicious material of the Bluff formation, and possesses very great fertility. In the Missouri bottoms, a black loam several feet in thickness occurs, and in the inland valleys a similar soil is found though with a less proportion of sand in its composition. The uplands are well adapted for the growing of the cereals, and the valleys afford the best of maize and meadow lands.

Fores's. Bordering the Missouri river there are considerable tracts of woodland, comprising a variety of trees among which the cottonwood, elm, and black-walnut predominate. In the neighborhood of Smithland, groves of native forests overspread the upland declivities, and form a narrow belt of woods on the banks of the Little Sioux for several miles above. In the northwest portion of the county other considerable bodies of timber occur along the Big Sioux and in the ravines that here intersect the uplands. The inland region, however, is a vast rolling prairie clothed with a luxuriant growth of herbage, but possessing scarcely a solitary shrub.

Springs are not of uncommon occurrence, and wells of excellent water may be obtained at almost any locality. The streams afford an unfailing supply of water, and the Little Sioux and Floyd rivers furnish valuable water-power which is already being improved at two or three localities.

Geology. The geological formations found within the boundaries of Woodbury county include those of the Post-tertiary and Cretaceous periods. The latter outcrops over a limited area in the northwest portion of the county, and it doubtless underlies its whole area.

Post-tertiary. The *Drift Formation* is readily recognized wherever it is found by the nature of the materials of

which it is composed. In the valley-slopes the gravel and boulder deposits appear at numerous localities and at various elevations, exhibiting all the inequalities of outcrop due to the extensive denudation these deposits were subjected to prior to the deposition of the superimposed Bluff formation. However, in this region, the Drift has not suffered near the same extent of denudation which swept away nearly its entire bulk in the region to the southward; and it is only upon the elevated outliers of the Cretaceous strata that these deposits are found attenuated to the appearance they more commonly present lower down the valley of the Missouri. At these localities the Drift is often represented by a thin bed of stratified gravel, as may be seen resting upon the unevenly eroded Cretaceous strata in Sergeant's bluffs at Woodbury and in the bluffs above Sioux City on the Missouri. At the latter locality, however, a thickness of about six feet of unmodified or glacial clay occurs, which in turn is overlaid by one hundred and thirty feet of Bluff Deposit. In the bluffs at the mouth of the Big Sioux the Glacial Deposits, consisting of blue clays charged with boulders and gravel, are exposed above the river level forty feet. These deposits occupy a depression of erosion in the Cretaceous strata, and, therefore, have not been denuded to the same extent as at the former and more exposed locality. There is no gravel deposit intervening between the glacial clays and the Bluff Deposit, which latter rises in almost precipitous heights one hundred and eighty-five feet above the Missouri.

The Bluff formation is found in all the higher elevations and in the divides between the watercourses throughout the county. Near Mr. Louis St. Onge's, seven miles above Sioux City, some of the higher eminences are three hundred feet above the Missouri river and about fifteen hundred feet above the sea. The view commanded from these ridges is particularly grand and impressive. To the northwest the great bottom-plain between the Big Sioux and the Missouri is lost in the distant horizon. And, to the southeastward, overlooking

in the foreground the Bluff and Drift capped Cretaceous escarpments, the eye catches, at a glance, a magnificent view of the Missouri valley as far down as the Little Sioux, in Monona county, bounded on the one hand by the treeless bluffs of Iowa, and on the opposite by the dark forest clad Blackbird hills on the Nebraska side. The impetuous Missouri, whose course is indicated by a belt of trees and now and then a gleam of its yellow flood, makes its way through the great flood-plain to discharge its sediment-burdened waters through the delta of the Mississippi into the Gulf. When the mind attempts to grasp the details of the early history of the great valley, the effort carries us so far back into the shadowy past that we can only vaguely realize the magnitude of the changes that then took place. However, as regards its later history, we have a key in the present operations of the great river which enables us to arrive at more satisfactory conclusions regarding the origin of the modern valley, than could be otherwise successfully sought. At one time the fine material of the Bluff formation occupied the entire valley in this region, as it does to this day the greater portion of the more ancient and far more extensive basin of the Missouri. The agencies that eroded the present valley were the same as those now in operation and which are still slowly deepening the channel and building up the bottom-plain by the deposits of the periodic freshets. The amount of material which has been removed and transported in the process of the excavation of the valley and its lateral valleys is almost incredibly immense. Assuming the average width of the valley to be five miles and its depth one hundred yards, and the tributary valleys at one mile wide and the same depth, with the least estimate the Missouri slope within the boundaries of Iowa alone has contributed to the alluvial formations of the Lower Mississippi upwards of three hundred and twenty billion tons of earth!

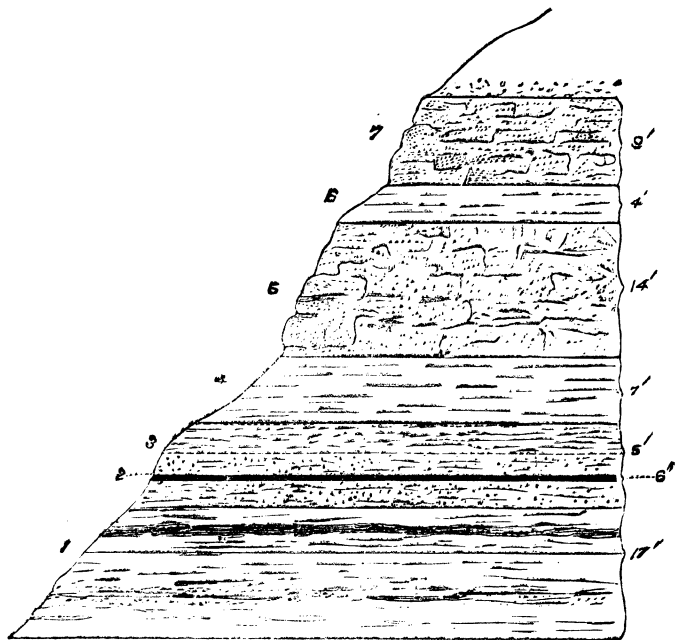
At Woodbury, the Bluff Deposit is seen resting immediately upon the Cretaceous strata; then again, a few feet of modified drift gravel intervenes. This formation in Woodbury county

is quite irregular in thickness, accumulating in the depressions produced by the erosion of the Drift and Cretaceous deposits, to the thickness of two hundred feet, and thinning to fifty feet, where those formations have been less extensively denuded. To the north and northeastward the Bluff gradually diminishes, and forty miles above Sioux City, the Drift Deposits constitute the more considerable portion of the uplands bordering the Iowa side of the Big Sioux, and the Bluff Deposit is only met with in patches of inconsiderable extent upon the higher eminences, it having been almost entirely swept away in the valleys.

Fossil remains are not common in this formation. It has, however, afforded a species of *Unio*, and the bones of buffalo are said to have been found in it. In the cut on the line of the Sioux City and Pacific Railroad, at Floyd's bluff, Helices were found in considerable abundance; but it

FIG. 87.

Section at Woodbury.



is difficult to determine whether these shells occur in the undisturbed Bluff Deposit, or were buried beneath the washings from the higher slopes: they seem to be confined to the edges of the cutting, and were not observed in the body of the deposit beyond a few feet from the surface near the base of the excavations.

Cretaceous. The most southerly outcrop of Cretaceous strata at present known in the county, is that which occurs in the lower portion of the bluff at Woodbury, where between fifty and sixty feet of sandstone and shales belonging to the lower formation presents the following section:

No. 7. Soft, yellow sandstone, in layers, 12 to 15 inches thick, with sandy partings, exposed 9 feet. Overlaid by the Bluff Deposit with sometimes a thin intervening gravel-bed.

No. 6. Yellow and blue, mottled clays, indurated, 4 feet.

No. 5. Rather heavy-bedded, soft, yellow sandstone, 14 feet. Contains Dicotyledonous leaves, *Sassafras*, *Salix*, etc.

No. 4. Blue clays, about 7 feet

No. 3. Light-yellow, arenaceous clays, about 5 feet.

No. 2. Dark carbonaceous band, 6 inches.

No. 1. Blue and light colored clays, more or less indurated, with arenaceous and ferruginous laminated layers, in places highly charged with charcoal particles and imperfect vegetable remains, 17 feet.

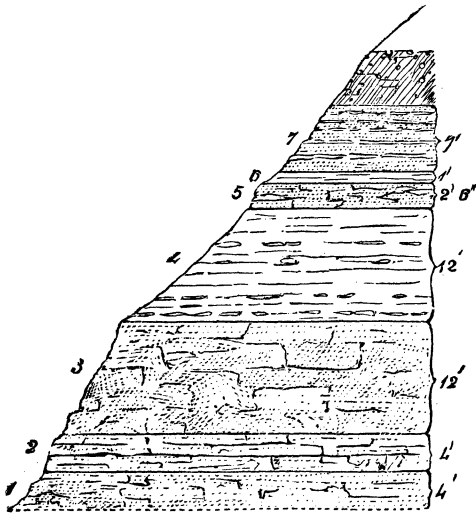
The base of the above section, which presents a general view of the strata at this locality, is about thirty-five feet above low water level in the Missouri river. A thin carbonaceous layer is said to occur in bed No. 4, but it was not to be seen at the time the exposures were examined. The strata have a slight southerly inclination.

In the bluffs above the mouth of Perry creek, at Sioux City, a fine exposure occurs which has often been cited by geologists and become to be regarded as typical of a portion of the Cretaceous series in the valley of the Missouri. During the examinations in this region, the present Survey is greatly indebted for valuable information and the gentlemanly coöperation of Mr. J. C. C. Hoskins, who is not only familiar with the geology of the region but is intimately acquainted

with the results of the numerous explorations made in the Upper Missouri country by Messrs. Meek and Hayden, Prof. Jules Marcou, and at an earlier day by Dr. Evans of the geological corps under the direction of Dr. D. D. Owen in the survey of the Northwestern Territories. The Missouri river at this point sweeps the base of the bluff, in the lower part of which the strata exhibit the following order of succession:

FIG. 88.

Section at Sioux City, on the Missouri.



No. 7. Soft, yellow sand rock, with nodular ferruginous bands, sometimes hard, shaly, brown sandstone layers, 7 feet.

No. 6. Ash-colored, gritty clays, 1 foot.

No. 5. Soft, yellow, laminated sand-rock, in places tough, shaly, and concretionary ferruginous rock, $2\frac{1}{2}$ feet.

No. 4. Blue, slightly arenaceous clays, with thin nodular ferruginous layers, 12 feet. In places the clay is quite dark, and an irregular, thin carbonaceous band or seam of brown-coal is sometimes found in the upper portion of the bed.

No. 3. Soft, yellowish, laminated, fine grained sandstone, with pink colored patches and ferruginous bands, 12 feet.

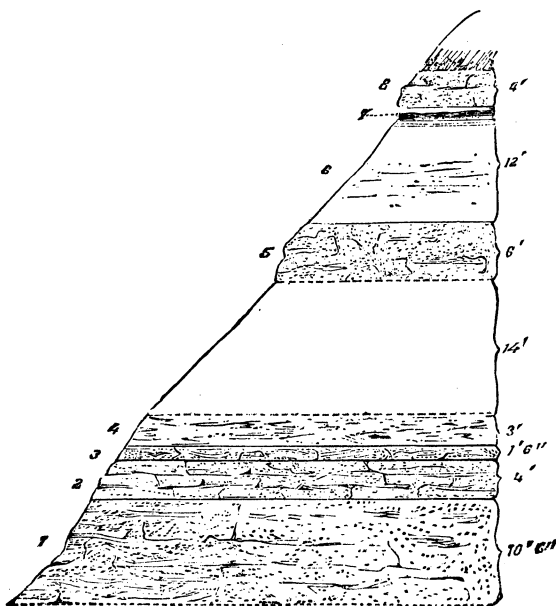
No. 2. Tough, grayish blue, shaly micaceous sandstone, finely laminated, and inclined to a concretionary structure, 2 to 4 feet. Contains *Dicotyledonous* leaves, *Salix*, etc., and a *Gasteropod*.

The section is capped by a thickness of five or six feet of gravel charged with blue clay, upon which the Bluff Deposit rises to the height of one hundred and eighty-five feet above the river. Bed No. 2, affords a good and very durable building stone, for which it is extensively used in the town. The carbonaceous layer in No. 4, seems to be an irregular band of rotten brown coal, and is of no economic value. These seams of brown coal are not uncommon in the Cretaceous strata in other parts of the State; but their occurrence, so far as known, does not indicate the presence of thicker deposits of coal in the accompanying beds. The concretionary, ferruginous layers in No. 7 afford an excellent article of mineral paint.

On Floyd river, a mile and a half above McDonald's mill, a low bluff rises close upon the right margin of the stream, in which is exhibited a thickness of from thirty to forty feet

FIG. 89.

Section at Bruguier's bluff on the Big Sioux.



of soft, heavy bedded, yellowish and red sandstone with irregular ferruginous partings. This exposure is probably the equivalent of the lower sandstone beds seen in the exposure shown in the preceding section. It is overlaid by an exposed thickness of two feet of blue shales, which may belong to bed No. 4 of that section. The rock is too friable to be valuable for building purposes.

Five miles above Sioux City, in Bruguier's bluff, on the Big Sioux, in section 23, township 89, range 48, the following section was obtained, presenting, essentially, the same strata as observed in the bluff exposures in the immediate vicinity of Sioux City:

No. 8. Mottled, red and yellow sandstone, 4 feet. The exposure at this point is capped by a thin bed of concrete, cemented with calcareous matter derived from the Bluff Deposit which forms the upper portion of the bluff.

No. 7. Thin carbonaceous layer, a few inches.

No. 6. Light-blue, gritty clays, imperfectly exposed, 12 feet.

No. 5. Red and light yellow, soft heavy-bedded sandstone, exposed 6 feet.

No. 4. Mottled, yellowish, and blue arenaceous clays, exposed about 3 feet, with an unexposed slope intervening between this and the overlying bed, No. 5, of about 14 feet.

No. 3. Soft, yellow, laminated, ferruginous sandrock, with leaves of *Sassafras*, 1½ feet.

No. 2. Tough, grayish, silicious rock, with thin micaceous partings, 4 feet. Charcoal particles are disseminated through the rock, and the leaves of *Salix Meekii*, and a minute species of Fern also occur at this locality.

No. 1. Soft, laminated, ferruginous sandstone, exposed 10½ feet—base above the ordinary level of the Big Sioux, 20 feet.

Bed No. 2, is an excellent building stone. It bears the closest resemblance to the quarry rock in the Bluffs at Sioux City, and contains the same fossils that are found at that locality. The associated strata, however, at first sight present a marked contrast to that exposure; but on comparing the two sections side by side, the contrast is found to be due to the exaggeration or diminution of arenaceous or argillaceous material in certain horizons, while the identity of the strata at the two localities is unequivocal.

Ascending the Big Sioux, about a mile above Bruguier's

bluffs, in the valley side near the Government bridge, the shelly *Inoceramus* limestone layers outcrop at an elevation of upwards of one hundred and twenty-five feet above the bottoms; but no satisfactory exposure is presented at this locality. About a mile above this, near Mr. Louis St. Onge's, the river washes the base of a considerable bluff escarpment, exhibiting one of the most interesting exposures of Cretaceous strata in this region. The river bluff exposure is capped by lower portion of the *Inoceramus* bed; and in the neighboring ravines at the Andrew Brother's quarries, and at Borowsky's quarry, and other similar outcroppings, this bed is well exposed, and derives much interest from the fact that it is the highest member of the Cretaceous series in the State. The following section gives a general view of the exposures at this locality, which is known as the Cedar bluffs:

Section at and in the vicinity of Cedar Bluffs, on the Big Sioux.

No. 26. Light gray, shelly limestone, with soft, calcareous partings, charged with *Rhizopods*, *Ostrea*, *Inoceramus*, and fish remains.

No. 25. Very light colored, chalky bed, resting upon light, calcareous clays belonging to bed No. 24, 6 to 8 feet, with abundance of fish remains, *Teliosts* and *Selachians*.

No. 24. Light colored, calcareous clays, with thin, shaly layers, containing *Inoceramus problematicus*, exposed at the top of the bluff escarpment, 4 feet. In the slope above, fragments of the "*Inoceramus* bed" are seen at an elevation of from forty to sixty feet above the base of No. 24, a vertical thickness which embraces all the quarry exposures in these layers in this vicinity, as described above.

No. 23. Fine, light colored clays, very slightly arenaceous, with fish remains, 22 feet.

No. 22. Compact, grayish laminated arenaceous rock, with fibrous gypsum and *Ganoid* scales, 10 inches.

No. 21. Buff, argillo-calcareous shales, middle portion arenaceous, with streaks of yellow and gray; lower part blue, slightly gritty, with an *Ostrea*-like shell and lenticular masses, containing fish remains, 17 feet.

No. 20. Shaly, fine-grained, ferruginous sandstone, with few *Ganoid* scales, 3 feet.

No. 19. Deep blue clay, with occasional sandy streaks, containing elegant groups of selenite crystals, and near the top, a thin layer charged with one or two species of a small *Lamellibranchiate*, 14 feet.

No. 18. Blue and yellow streaky clays, containing selenite, and capped by a thin, irregular nodular band, 4 feet.

No. 17. Hard, ferruginous, laminated layer, highly charged with *pyrite*, 6 inches.

No. 16. Blue, slightly gritty clays, 6 feet.

No. 15. Irregular, rather compact, ferruginous layer, 6 inches.

No. 14. Soft, grayish sandrock, with thin, ferruginous laminae, 3 feet.

No. 13. Thin, carbonaceous clay, with charcoal-like material, 1 to 3 inches.

No. 12. Bluish clays, 5 feet.

No. 11. Irregular, nodular, ferruginous band, 6 inches.

No. 10. Blue clays, like No. 8, slightly arenaceous in the middle, with imperfect vegetable remains, $5\frac{1}{2}$ feet.

No. 9. Irregular, hard, nodular band, 6 inches.

No. 8. Soft, blue clays, in places charged with carbonized vegetable remains, $5\frac{1}{2}$ feet.

No. 7. Very soft, yellow sandrock with dark, ferruginous bands, capped by a three-foot layer of rather compact, yellow, ferruginous sandstone, in which imperfect Angiospermous leaves and coaly particles occur, 9 feet.

No. 6. Blue, arenaceous clay, $2\frac{1}{2}$ feet.

No. 5. Compact, grayish, silicious layer, like No. 2, 3 to 6 inches.

No. 4. Blue clays, passing upward into laminated, arenaceous shales, with thin, ferruginous layers, 8 feet.

No. 3. Very soft, dirty yellow, laminated arenaceous bed, bluish, slightly gritty clays, with dark brown, irregular, ferruginous layers below, 7 feet.

No. 2. Hard, gray, silicious rock, with thin, shaly, ferruginous layers, containing leaves of *Salix Meekii*, and carbonized vegetable remains, 20 inches.

No. 1. Brown and light colored friable sandrock, exposed to ordinary water level in the Big Sioux, 7 or 8 feet.

The above represents a complete section of the Cretaceous strata in this region, including in its lower half the equivalents of the beds observed at all the preceding localities in the county. Number two is the same as the bed bearing the corresponding number in the sections at both Sioux City and Bruguier's bluff, and here as there, it affords an excellent building stone. This bed is not exposed at Woodbury, and, indeed, it may be wanting at that locality. The carbonaceous horizon, (No. 13), also presents the same association of argillaceous and arenaceous beds below and above, that characterize this horizon at the before mentioned localities. But there is a marked diminution of arenaceous material at this locality, though the stratigraphical order of the beds

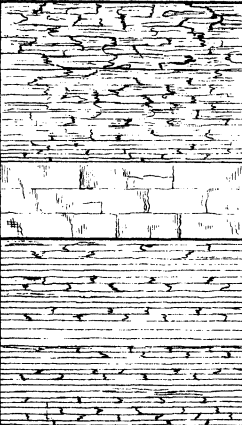
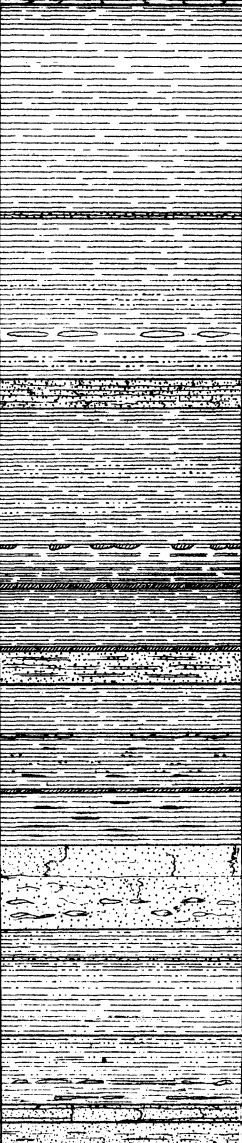
remains essentially the same. The beds, Nos. 25 and 26, are seen at numerous points in the bluffs bordering the ravines a short distance from the river. They have been extensively quarried for burning into quick-lime, but for building purposes the rock is worthless. The finest exposure of these upper or "Inoceramus beds" is that at the Andrew Brother's quarries, five miles northwest of Sioux City. The fish remains of these beds are largely composed of Teliosts—the representatives of the common bony fishes—and the teeth and vertebræ of sharks of the genera *Lamna* *Corax* and *Ptychodus*. The shaly layers, (No. 26), are crowded with the fragmentary remains of *Inoceramus problematicus*, besides a small oyster, *Ostrea congesta*, and the exuviae of a Rhizopod occur in innumerable numbers in certain layers. Bed No. 25 is almost a pure chalk, there being but a small percentage of ferruginous and earthy matter in its composition.

Two miles above St. Onge's, and also opposite the mill on the Big Sioux, three miles above the mouth of Broken Kettle creek, in Plymouth county, the same strata are again met with. At the lower locality, near Mr. John Harden's, in section 22, township 90, range 48, the Inoceramus or shelly limestone bed appears in the top of the bluff ridge one hundred and ten to one hundred and thirty feet above the Big Sioux. In the lower part of the bluff, seventy-five to ninety feet below the upper bed, the sandstones, shales, and arenaceous, ferruginous layers overlying the carbonaceous horizon, outcrop. The latter layer was not seen at this locality, though it doubtless exists beneath the detrital material covering the slope. At the locality above the Broken Kettle—to which I was accompanied by Mr. Louis St. Onge, to whom we are indebted for the generous hospitality he showed our party, and the assistance he rendered in various ways during the examinations in this section of the State—a fine exposure of the lower beds occurs, showing an unusual development of sandstone, including the thin carbonaceous layer thirty feet above the river level. High in

GENERAL SECTION

OF

Cretaceous Rocks on the Big Sioux above Sioux City, Woodbury Co.

<p>26 Light grey shaly Limestone, with thin calcareous partings charged with Rhizopods, Ostrea, Inoceramus, and Fish-remains.</p> <p>25 Light, chalky bed, charged with Fish-remains.</p> <p>24 Light, calcareous shales, with thin shaly layers, containing Inocerami.</p>		<p>17'</p> <p>8'</p> <p>20'</p>	INOCERAMUS BEDS.
<p>23 Fine, light colored shales, slightly arenaceous, with fish-remains.</p> <p>22 Compact, greyish, laminated, arenaceous rock with fibrous gypsum and fish-scales.</p> <p>21 Buff, argillo-calcareous shales - middle portion arenaceous, with streaks of yellow and grey, lower part blue, slightly gritty; with an Ostrea-like shell, and lenticular masses containing fish-remains.</p> <p>20 Shaly, ferruginous, fine-grained sandstone.</p> <p>19 Deep blue clay, with occasional sandy streaks, with groups of selenite crystals, near the top thin layer, charged with one or two species of a small Lamellibranchiate.</p> <p>18 Streaky blue and yellow clay, with selenite, capped by a thin irregular nodular band.</p> <p>17 Hard, ferruginous, laminated layer, charged with pyrite.</p> <p>16 Blue, slightly gritty clay.</p> <p>15 Irregular, compact, ferruginous layer.</p> <p>14 Soft, greyish, sand rock, with thin ferruginous</p> <p>13 Thin carbonaceous layer. laminae</p> <p>12 Blue clays</p> <p>11 Irregular, ferruginous, nodular band.</p> <p>10 Blue clays, slightly arenaceous, with plant remains.</p> <p>9 Irregular, hard nodular band.</p> <p>8 Soft blue clays, in places charged with carbonized vegetable remains.</p> <p>7 Soft yellow sandstone, with dark ferruginous bands, capped by 3 feet of compact sandstone, with leaves and coal particles.</p> <p>6 Blue arenaceous clay.</p> <p>5 Compact, grey sandstone, like No. 2.</p> <p>4 Blue clays, laminated arenaceous above, with thin ferruginous layers.</p> <p>3 Soft laminated arenaceous bed, blue slightly gritty clays below, with ferruginous bands.</p> <p>2 Compact grey sandstone. Plants</p> <p>1 Friable sandrock, brown and light colored.</p>		<p>22'</p> <p>10"</p> <p>17'</p> <p>3'</p> <p>14'</p> <p>4'</p> <p>6"</p> <p>6'</p> <p>6"</p> <p>3'</p> <p>3"</p> <p>5'</p> <p>6"</p> <p>5' 6"</p> <p>5' 6"</p> <p>9'</p> <p>2' 6"</p> <p>6"</p> <p>8'</p> <p>7'</p> <p>20"</p> <p>2' 6"</p>	WOODBURY SHALES AND SANDSTONE.

the bluffs, one hundred and twenty feet to one hundred and thirty feet above the river, the "Inoceramus bed" outcrops. The carbonaceous layer at this locality presents the appearance of a mass of partially carbonized vegetable debris, with pocket-like accumulations of brown coal. The sandstone is too soft to answer for building purposes, and the hard quarry rock seen at Sioux City, and at other places, is several feet beneath the bed of the stream at this locality.

Comparing the respective elevations of the "Inoceramus beds" at the two extreme points of the outcrop, it will be observed that the strata have a gentle northwesterly inclination which carries the upper beds down to a level but little above the river opposite Indian creek, in Dakota, thirty miles above Sioux City, which is the most northerly exposure of Cretaceous rocks at present known on the Big Sioux.

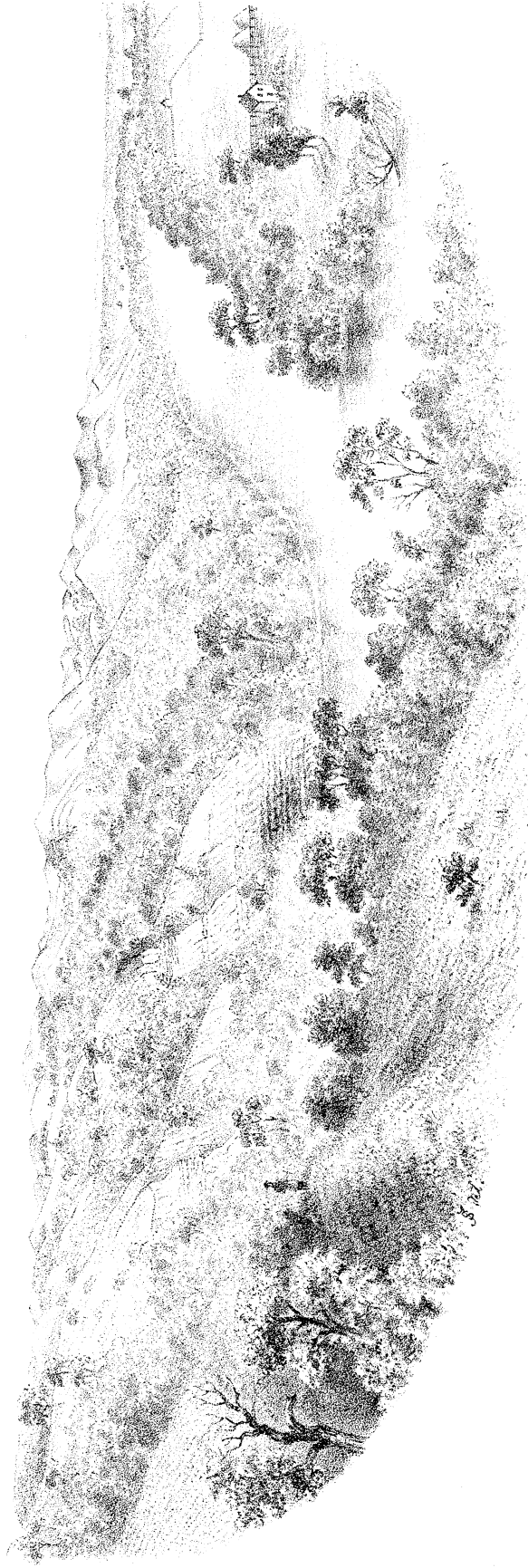
Economical Geology. Coal and Fuel. The thin carbonaceous layer found at several localities in the Cretaceous rocks has given rise to considerable speculation as to the probable existence of more extensive deposits of coal in this region. But so far as our examinations have extended—and they have included every known rock exposure in the county—we have seen no indications that would justify such a supposition. For the present wants there is an abundant supply of fire wood, but when the county shall have become more densely populated, the lack of wood for fuel will necessitate the growing of artificial forests, which, besides having a direct practical bearing, will contribute immeasurably towards enhancing the appearance of the great prairies of Western Iowa.

Building Materials. The compact silicious rock in the lower part of the Cretaceous Deposits in this county, affords at several localities a very good building stone. The heavier sandstone beds in this formation, however, are too friable to answer even the most ordinary purposes in masonry. The upper shelly limestone and chalky beds furnishes material for burning into quick-lime, which is said to be of fair quality, though not as strong as that made from the carboniferous and Devonian limestones. At Sioux City the surface-

washings of the Bluff Deposit is used for making brick. The decomposition of the calcareous nodules for a few feet from the surface in exposed situations, renders this material as available for brickmaking as the clays derived from the Drift Deposits in other parts of the State.

Potter's Clay. The fine clays in the Cretaceous Deposits furnish an excellent material for potters' use. At Woodbury, Messrs. Neff and Wurtman have an establishment where this branch of industry is carried on quite extensively. In certain fine silt deposits in the banks of the Missouri, close at hand, the material for glazing the ware is obtained.

Mineral Paint is obtained from certain ferruginous layers, in the bluffs at Sioux City, but probably not in sufficient abundance to warrant any outlay in developing this branch of manufacture. But it is not upon its stone, coal, and other mineral productions, that Woodbury county relies for its material prosperity. Its prairies are of the finest and most fertile in the State, and the geographical situation of the county could be hardly more favorable for the building up of a substantial and prosperous commercial community.



Mills & Co. Lith. One Mones.

CRETACEOUS EXPOSURES ON THE BIG SIOUX AT ST ONGE'S, WOODBURY CO.

(Looking Southward 1868.)

CHAPTER II.

NORTH WESTERN IOWA.

1. GENERAL DESCRIPTION.

The region, here designated as Northwestern Iowa, comprises four counties in each of the three northern tiers, twelve in number. They are Pocahontas, Palo Alto, Emmett, Dickinson, Clay, Buena Vista, Cherokee, O'Brien, Osceola, Lyon, Sioux, and Plymouth.

The Big Sioux river, which forms a part of the western boundary of the State, also constitutes the whole of the western boundary of this region, and the northern boundary line of the State is also its northern boundary. Its northern and southern boundaries being parallel east and west lines, its eastern boundary a straight north and south line, and the Big Sioux having a nearly southerly course, the outline of the region is nearly that of an oblong parallelogram. Its greatest length from east to west is about one hundred and ten miles, and it is about sixty-five miles wide from north to south. Its superficial area is estimated at six thousand nine hundred and ten square miles, or four millions, four hundred and twenty-two thousand, four hundred acres.

The whole region is generally very well drained, although a large part of it is occupied by an unusually flat portion of the Great Watershed, and in consequence, its streams are usually small. The principal streams of the region are the Little Sioux, Floyd, and Rock rivers upon the Missouri river side of the Great Watershed, and the Upper Des Moines

river, which collects the waters from the eastern counties of the region for the Mississippi drainage. In those counties through which the Great Watershed passes, there exists quite a number of lakes resting entirely within comparatively shallow depressions in the drift. They are such as have been designated in a previous chapter as drift lakes. Marshes are also occasionally found distributed upon the surface of this summit region, but even where these are most numerous, it must not be inferred that any large proportion of the surface is occupied by them. A large part also of those that really exist there may yet be drained and reclaimed to cultivation. Some of the lakes of this region are very beautiful and interesting, especially lake Okoboji, and Spirit lake, both of which are described and illustrated in another part of this report.

This region includes the most elevated portion of the State, and yet its highest point of elevation is only about seventeen hundred feet by estimate, above the level of the sea, and only between twelve and thirteen hundred feet above the lowest point in the State, which latter point is at its southeastern corner. So few levels have been made within the limits of the region, for railroads and other purposes, that it is not known precisely where the highest point is, or what is its actual elevation, but judging from levels made in other parts, from the known slopes of rivers and the positions of the streams which drain the region, it is inferred that the highest point within its limits, and also the highest within the State, is in the immediate vicinity of Spirit and Okoboji lakes, in Dickinson county. Except by estimates from such data as these, or by actual leveling, the relative height of the different portions of the region cannot be ascertained, nor their difference hardly suspected, because the difference never amounts to enough to be detected by the eye of the traveler as he crosses it in any direction. It is true that the surface is always gently undulatory, sometimes "knobby," and occasionally traversed by a shallow valley, but as the view is almost nowhere obstructed by trees, he is always able to

distinguish a general plain, distinct from such local elevations and depressions, as his vision falls upon the surface in the distance. This general plain usually appears to the eye to be everywhere a perfect level, so slight are the variations of altitude in the general surface.

Taken as a whole, the surface of this region is, probably, less broken by deep valleys and ravines than any other part of the State. Even in the vicinity of the larger streams—the Big Sioux, Little Sioux, Des Moines, etc.—the valley slopes are usually gentle and undulatory, and as there are no rocky bluffs in the whole region, the steepest valley-sides are such as remain where the streams have cut their valleys out of the drift alone. When it is remembered that the streams of the region have nowhere, except at its eastern and western borders, cut their valleys down to the stratified rocks, but that the valleys of all the streams which traverse it have been excavated out of the deep and incoherent drift alone, it will be understood that the general surface is necessarily unmarked by strong physical features. The plain-like monotony of surface that is now so wearisome to the traveler is largely due to the almost entire absence of trees. There is really quite enough diversity of surface to give the region a pleasant aspect if those distant stretches of unobstructed view were frequently relieved by the presence of groves and larger bodies of forest trees. The largest bodies of woodland now to be found in the whole region are in the vicinity of Spirit and Okoboji lakes, and at several points along the valley of the Des Moines. Aside from these, there is no woodland except the narrow, interrupted belts which usually exist along the borders of the larger streams, and a few clumps and small groves near the smaller lakes. Even the larger upper branches of the rivers are prairie streams, with only occasional clumps of willows to relieve the monotony of the uniform grassy surface.

A large proportion of the marshes of the Middle region of northern Iowa are filled with peat, but those of the adjacent part of the region under discussion are not, generally

peat marshes. Two or three very good peat marshes were found in the neighborhood of Spirit and Okoboji lakes, and smaller quantities were observed elsewhere, but the indications are that nothing like a general supply of this kind of fuel, except for a few neighborhoods, exist anywhere in the region. All that exists then may be expected in the eastern half of it, because in the whole six counties of the western half, marshy land is very rare.

The Soil of this region is characteristic drift soil, and it almost everywhere has a uniform general character. It is true that in Plymouth county, in the extreme southwestern corner of the region, we find the northern border of the Bluff Deposit which there, resting upon the drift, forms the soil, the character of which has been fully described in another chapter. The soil of the bottoms of the valleys also, especially those of the Big Sioux and Des Moines, is more or less alluvial in its character, but all, except these fractions of the soil of the whole region, is that of the undisturbed drift. The drift soil of Northwestern Iowa, differs somewhat from that of the same deposit in other parts of the State. It contains, as a rule, a greater proportion of sand and less clay, which imparts physical properties to it that are very beneficial in agriculture, for it must not be supposed that, except in a few insignificant instances, the sand is sufficient in amount to cause any approach to barrenness. There are, indeed, very few spots in the whole region, even in the valleys, that can be properly said to have a sandy soil. Occasionally the "knobs" are found to be gravelly and more or less barren, but these exceptions are so rare that probably no region in the State or elsewhere has a smaller proportion of untillable land. This fortunate admixture of soil-materials give a warmth and mellowness to the soil which is so favorable to the growth of crops that they are usually matured, even in the northern part of this region, as early as they are upon the more clayey soils of the southern part of the State, although the latter are two hundred miles farther southward. Such a soil has also the additional

advantage of becoming sufficiently dry to cultivate sooner after the frosts of early spring have ceased, or the rain-showers of summer have ended, than those do which contain a greater proportion of clay.

The maximum thickness of the drift of this region has not been ascertained, but it is known to be very thick. As has been shown in another chapter, we have evidence that it is thicker along the course, and in the vicinity of the Great Watershed than elsewhere within the limits of the State. Indeed this watershed is evidently formed largely of drift alone; but, of course, the central elevation of the State is not all due to the thickness of the drift. None of the streams of this region, except those near its eastern and western borders as before remarked, have exposed any of the underlying strata in the process of deepening their valleys, yet in a few places, the streams have cut out their valleys in the Drift Deposit so abruptly that one almost instinctively expects to find strata exposed there in the valley-sides. The valley of the Little Sioux presents such characters near Peterson, in the southern part of Clay county. Here the valley of the river has the character of a well-defined gorge which, from brow to brow of the abrupt slopes, is only about a quarter of a mile, while the depth from the general prairie level, which is distinctly defined in the adjacent region, is one hundred and ninety feet to the water in the stream. The valley slopes here are necessarily steep, and one would naturally look for exposures of strata under such circumstances, if anywhere in the region, but careful search failed to show a trace of anything besides the disturbed drift, from top to bottom of the valley. It may be that the Cretaceous strata, which we find farther southward and westward, exists here also beneath the drift, and, being so friable, they may have become covered by their own debris, together with the overlying drift if they had ever been exposed. If this whole depth, however, of nearly two hundred feet is entirely of drift material, it is very remarkable, and yet there seems no reason to doubt, that the drift alone may have that thickness here,

particularly as we have just as good reason to believe that it is nearly or quite as thick along the Great Watershed to the southward.

2. GEOLOGY.

The exposures of strata in this region, although so few in number and so small are, nevertheless, very interesting from the fact that they occupy extreme points within the region and at each point the strata exposed represent respectively widely separated epochs in geological time. These strata are exposed at only three localities within the region which are so limited that they may be designated as points. The first is in the extreme eastern part of the region, near the eastern border of Pocahontas county. The strata are of Sub-carboniferous age. The second is in the southwestern corner of the region and of Plymouth county, the strata being of Cretaceous age. The third is in the extreme northwest corner of the region and of Lyon county, where the strata exposed are of Azoic age.

The first named exposure is found near Lizard creek, about six miles southward from Rolfe, the present county seat of Pocahontas county, and is referred without doubt to the Kinderhook beds, which constitute the lowest formation of the Sub-carboniferous group. This locality is interesting as being the most northerly and westerly point at which the strata of this or any other Sub-carboniferous formation are found exposed; and it is also the most westerly point at which any palæozoic strata have been observed within the limits of the State. The strata at this locality consist of thin layers of gray limestone, which is in some parts slightly oolitic, but it is mostly of a sub-crystalline texture. The exposures are slight and inconspicuous and confined within a very small space upon the gentle slope of the prairie valley, yet considerable quantities of stone for ordinary use and for lime have been and much more may be quarried here.

The second exposures named are those of Cretaceous age, and are found in the bluffs that border the valley of the Big

Sioux river, near to and below the mouth of Broken Kettle creek, in the southwestern corner of Plymouth county. The strata exposed here consists of parts of both divisions of Cretaceous rocks, designated in another part of this report as the "Woodbury Sandstones and Shales," and the "Inoceramus Beds." The first are all so friable and soft that they are in this region hardly fit for any economical purpose. The latter are composed of the usual soft chalky material and the thinly laminated, chalky limestone. In consequence of the friable character of all these strata their own debris almost everywhere covers them from sight where they were once probably exposed, so that they are only seen in the steepest slopes of the bluffs, and there but rarely. There is reason to believe that they do now or originally did underlie all the surface of the western part at least of this region, up to and beyond the northern boundary of the State, —resting there directly upon Azoic strata—although they now nowhere appear within the limits of the State north of the center of Plymouth county. The fact that these strata are found at several points in southwestern Minnesota is itself very good evidence that the strata there were originally connected with those found in Iowa. Going northward from these exposures in Plymouth county, the next exposures of strata are found in the extreme northwest corner of the State. These are the Sioux Quartzite and are regarded as of Azoic age. The character of this rock has been fully described in a preceding chapter and need not be repeated here.

It will thus be seen that it is only upon the extreme eastern and extreme western borders that any exposures of strata whatever are found and consequently almost the whole region is without any exposure of rock of any kind except an occasional boulder imbedded in the soil. But the region comprised in the twelve counties here designated as Northwestern Iowa is not the whole of the great stoneless region of that part of the State. If a square be drawn upon the map of Iowa which shall represent one hundred miles eastward and westward and the same distance northward and south-

ward, whose northern side shall be the northern boundary of the State and whose eastern side shall be the line which separates the twenty-ninth and thirtieth ranges of townships, *it would represent ten thousand square miles upon which no exposures of rock in place were to found, except those limited ones in Pocahontas county*, besides which, the only stone of the region consists of the sparsely scattered boulders. Even this is not all of the great stoneless region of Northwestern Iowa. The area just designated would include only the northern portions of Monona, Crawford, and Carroll counties. There are no exposures of strata in any part of either of these so far as yet discovered, nor in either Audubon or Shelby counties which adjoin them on the south. Again, upon the eastern border of the square indicated, lies Kossuth, Crocker, Winnebago, and Hancock counties, in neither of which has there been a single exposure of strata discovered, and no stone to be seen except the usual sparsely scattered boulders. The uncolored portion of the geological map accompanying this report represents more fully the outlines of this great stoneless region.

With perhaps the exception of an occasional artificial excavation, which may in the future throw some light upon the subject, our knowledge of the character and extent of the formations that occupy this region immediately beneath the drift must be derived by inferences from the results of examinations made in the regions adjoining, and from knowledge previously acquired concerning the general dip and trend of all the other formations of the State. Upon a lithographed sheet, accompanying this report, a section is represented extending from McGregor, upon the bank of the Mississippi, in a straight line across the State to the mouth of Broken Kettle creek in Plymouth county. If one travels westward upon this line he will have passed over the whole unbroken series of palæozoic strata from the Potsdam sandstone to the Sub-carboniferous, inclusive, when he reaches the exposure of Kinderhook limestone, in the eastern part of Pocahontas county, before mentioned, and which lies directly

upon this line. All these formations pass successively beneath each other with a slight westerly dip, which although considerable, especially along the eastern portion of the line, is really much less in the aggregate than it appears to be, from the fact that the gradual rise of the surface to the westward, amounts to a large part of the aggregate thickness of all the formations passed over. The Kinderhook member of the Sub-carboniferous group disappears in turn beneath the almost unbroken drift mantle of the northwestern part of the State, and is seen no more. If we continue westward upon the same line, the next exposures we find of rocks in place are those of Cretaceous age, at the mouth of Broken Kettle creek, in Plymouth county. If we go northwestward from that point in Pocahontas county, we find no exposures until we reach those of Azoic age, in the extreme northwest corner of the State, and in a northerly direction we must go far beyond the limits of Iowa, into the valley of the Minnesota river, before we find a single exposure of rocks in place. Those we find there are of Azoic age, the same formation, in fact, as the Sioux Quartzite, which we find at the surface in the extreme northwest corner of Iowa.

Southward from this area here designated as Northwestern Iowa, all the strata exposed within the limits of the State belong to either the Lower, Middle, or Upper coal-measures. These three formations together with those of all the palæozoic rocks in the State, are known to have a general southerly or southwesterly dip. We have evidence, however, that those portions of the coal-measure formations that lie westward from the valley of the West Nishnabotany, have a slight general dip, which is a little to the north of westward, that river apparently running upon the very slight anticlinal axis thus formed. This dip, slight as it is, together with the opposite slope of the surface, soon carries the Upper coal-measure formation beneath the Cretaceous strata of Nebraska, and they are seen no more in that direction until they come to the surface again near Salt Lake, about a thousand miles away. But with the slight exception named, so far as Iowa

is concerned, the general dip, as before remarked, is a little to the west of southward, for the coal-measure formations as well as for all the other palæozoic strata. Consequently when we find the most northerly exposures of those three formations in Harrison, Guthrie, Greene, and Webster counties, and crossing the great stoneless area to the northward and find that the strata exposed at the surface on the north side of it are of Azoic age, we cannot doubt that those coal-measure formations have thinned out beneath the Drift Deposit somewhere within the limits of that area, probably near its southern border. We not only have proof that these later palæozoic formations have thus thinned out to the northward, but facts before mentioned, also prove that all the other formations of palæozoic age, comprising the whole of those in the eastern part of the State, have also thinned out to the westward and northwestward before reaching the northwest corner, where, as before said, the Azoic rocks appear at the surface. Some of those earlier palæozoic formations, which disappear in succession as one approaches this region from the eastward, may end beneath the others before they reach so far westward as the borders of the region under discussion, but the later ones, particularly the Sub-carboniferous, must of necessity thin out somewhere beneath the drift, or possibly beneath Cretaceous strata also, within its borders.

Now arises a question of great practical importance to the inhabitants of this region. It has been shown that the coal-bearing formations necessarily end by thinning out somewhere beneath the drift of this broad stoneless area, but as this area is a hundred miles and more across, it is desirable to know with as much accuracy as possible, how far they extend to the northward of the points where they are last seen upon the surface. It is desirable to know this, so that any future explorations for coal that may be made in this region, may be undertaken intelligently. In reply to this question, the opinion is advanced that it is not probable that profitable beds of coal will ever be found north of a line running

directly westward from Fort Dodge. The Lower coal-measures, the formation which is known to contain the greater part of the coal of Iowa, it is true, is found well developed and quite productive as far north as Fort Dodge, in Webster county, but westward from this county nothing more is seen of it. We have seen that the northern borders of the other two formations of the coal-measure group have a general trend or direction a little north of west, and we may consequently infer that the northern border of the lower and most productive of these formations has a similar trend, approximately parallel with the others. This being the case the northern border of the Lower coal-measure formation, although not exposed to view at any point westward from the vicinity of Fort Dodge, may be inferred to exist not far from the northern limits of Calhoun, Sac, Ida, and Woodbury counties, because the northern limits of that formation are found to be near such an east and west line in Webster and Hamilton counties. Notwithstanding the fact that good workable beds of coal are found near the northern border of the coal-field in the counties of Hardin, Hamilton, and Webster, and the great probability that it may also exist just as near that portion of its border which is continued beneath the surface to the westward of those counties, it cannot be denied that the chances of discovering a workable bed of coal within the region here designated as Northwestern Iowa are exceedingly small. If workable beds of coal really existed in the region, the exposures of any strata at the surface are so few, which might give any indication of their presence, that the hazard of finding them would be very great, particularly as all such explorations must be made by sinking shafts at random without any indication to suggest the choice of one point in preference to another. In short, it is at present believed that all attempts to discover a profitable bed of coal in the region here designated as Northwestern Iowa, will result in a waste of labor and money, although it is not at all improbable that small basin-outliers of true coal-measure strata may be discovered within its limits by future artificial excavations.

The question of a supply of coal is one in which the people of the State have the greatest interest. Indeed its practical importance can hardly be overestimated. To the geologist, however, in a mere scientific view, the question of the actual boundaries of the formations that are lost beneath this broad drift mantle, is just as interesting. Approaching this region from the east, he sees the Sub-carboniferous limestone disappearing beneath it to the westward. Approaching it from the west he sees the Cretaceous strata disappearing beneath it to the eastward in like manner upon its very borders; and approaching it from the north or northwest he sees the Azoic strata passing beneath it to the southward, while the broad space, a hundred miles or more across it in every direction, is a perfect blank so far as regards the exposure of these or any other stratified rocks.

How far the palæozoic rocks extend beneath it from the eastern border, we do not know, and probably never can know. We have only the evidence in the fact of the existence at the surface in the northwestern corner of the State, of Azoic strata, that they thin out somewhere within the limits of the region. How far that particular formation of the Azoic rocks, the Sioux Quartzite, extends to the southward and eastward beneath the surface of the State, we can probably never know. How far the Cretaceous strata which appear upon the southwestern margin of the region, extend over the remainder of it, unseen beneath the surface now covered by the drift, is not now known because no exposures of them are found there. We have, however, many reasons to believe that the last named strata once covered nearly, if not quite the whole region, and that a large part of them, being all very friable, were removed by erosion during the Tertiary age, and much more swept off by glacial action during the Drift or Glacial epoch, and the remainder are now mostly covered by the drift. Besides more or less indistinct indications of the correctness of this view, gathered from observations within the region itself, we find traces of Cretaceous strata at several points within the State of Minnesota, extending as far as, or farther

to the eastward than the eastern border of the region under discussion. Frequent exposures of strata of Cretaceous age exist also to the southward of it, and also to a point in Guthrie county, as far eastward as the eastern border of this region; and, although no exposures of these strata now appear at the surface in the intermediate space, judging from the uniformity of the surface, and from our knowledge of the position that the underlying strata must necessarily assume, it is inferred that the whole intermediate region originally received deposits of Cretaceous strata continuous with those that now appear.

These Cretaceous strata everywhere, both in Minnesota and Iowa, show evidence of extensive glacial and other denudation. This has been accomplished with facility in consequence of the great softness and friability of all the strata of that age. The denudation of these strata has been so great that their remains now exist in some parts only as scattered outliers resting upon older rocks. In Western and Southwestern Iowa, they are found resting unconformably upon the Upper, Middle, and Lower coal-measures successively; and in Minnesota and Dakota they are found resting upon Azoic rocks.

The foregoing views concerning the real and supposed relations of strata of Northwestern Iowa to each other and with those of other parts of the State, are illustrated by the lithographed section accompanying this report before referred to. The dotted lines upon those sections indicate the *supposed* relative position of the strata beneath the great drift region where they are all covered from sight, while the continuous lines are given as the legitimate result of actual examination.

3. MATERIAL RESOURCES.

After the foregoing description of the geology and physical geography of this region it will necessarily be inferred that aside from the great fertility of its soil its material resources are at present very limited. As far as mineral

resources, properly speaking, are concerned, they are, so far as at present known, the least that could well fall to the lot of an equal area of the earth's surface anywhere; for the drift covers the whole surface so deeply and completely that whatever of mineral wealth may possibly exist beneath it, is as effectually hidden as if it were covered by the waters of the sea. The only items coming under the head of the last named resources are the slight exposures of stone before referred to. These will be mentioned further on in the descriptions of the counties in which they occur.

The great fertility of the soil and the minuteness of the proportion of it that is untillable, have already been mentioned. It has been believed by many that a large part of this region has a barren soil, but the truth is the proportion of the surface rendered untillable by the occupancy of the barren "knobs" and marshes, or by any other cause, is so small that it would attract no attention in the most fertile regions outside of Iowa.

Notwithstanding the fact that this fertile soil now produces little more than an annual crop of grass, it is from the soil almost alone that the future wealth of the region must be derived, and the inhabitants will not be disappointed in their dependence upon it. Not only will it supply a dense population with abundant food, but it will also yield them just as certain and abundant supplies of fuel in the shape of forest trees if they are only planted and protected from the ravages of the prairie fires. Although Northwestern Iowa is now more distinctively a prairie region than any other part of the State, it is these fires alone that keep it so. The power and magnitude of these annual scourges can hardly be understood by those not familiar with them, but some idea of them may be formed by reference to the extensive areas over which they sweep. As one goes northward from the southwest corner of the region, as soon as he leaves the vicinity of the Missouri river, which near this point bends away to the westward, he finds himself upon an immense prairie region. Far away to the eastward it is almost

unbroken until the Des Moines river is reached, and here it is only separated from a wide prairie region beyond, by a narrow strip of woodland in the valley of that stream. Still farther than this to the northward, into Minnesota, the same continuous prairie surface stretches, extending even beyond the Minnesota river, which interposes its woodland valley like a mere line. Farther still to the westward towards the Rocky Mountains, the same almost unbroken continuity of fruitful soil is annually rendered desolate by the fires that sweep its surface, unobstructed in many places even by the larger streams, for it often leaps these when the wind is high, and carries on its work of destruction beyond.

Whatever may have been the original cause of the absence of trees upon these and other prairie regions, we have the evidence that it is the annual fires and these alone that now prevent them from spontaneously occupying the soil. In all abrupt bends, and upon all islands of the Big Sioux and other principal streams of the region, forest trees are growing thriftily, because they receive, at least, partial protection from the fires by the adjacent water; and wherever clumps of fire-stunted trees have received incidental protection by the opening of farms, or wherever the settlers have planted and protected any of the indigenous trees, they rapidly assume forest proportions. With these facts before us, we cannot doubt that a few years will suffice to convert the whole of this treeless space into a well cultivated region with a sufficient amount of artificially planted woodland from which to supply the wants of the inhabitants. In view of these facts, also, no doubt can be entertained that the soil of Northwestern Iowa is the source of abundant and sufficiently diversified material wealth, the development of which will be fully entered upon in the immediate future.

4. EMMET AND PALO ALTO COUNTIES.

Emmet county is one of the northern tier, the eighth from the Mississippi on the east, and the fourth from the western

boundary of the State. Palo Alto county adjoins, and lies directly south of it. They both together contain twenty-eight congressional townships, Emmet containing twelve, and Palo Alto sixteen. The northern tier of townships in the State being only five miles wide from north to south, Emmet county lacks twenty-four square miles of the full superficial area of twelve townships. Its area is consequently only four hundred and eight square miles, while that of Palo Alto is five hundred and seventy-six square miles, giving for both counties the aggregate number of six hundred and twenty-nine thousand, seven hundred and sixty acres.

The Des Moines river traverses these two counties, entering Emmet at its northwestern corner, and passing out of Palo Alto at the southeastern corner of the latter county. The East fork of the Des Moines also passes across the northeastern corner of Emmet, but is there a very small stream, since its source in Lake Okamanpadu is upon the northern border of the same county. The other streams that drain these counties are both few and small. Although the Des Moines, the largest stream in this part of the State, traverses both these counties, they have nevertheless largely the characters of a summit region. They are indeed among the most elevated counties in the State, the Great Watershed passing along the western part of both of them. Along this broad summit region, which constitutes that portion of the Great Watershed in this part of the State, as well as the secondary watershed between the main branch and the East fork of the Des Moines, there are numerous small lakes of clear water resting in shallow depressions in the drift. These of course do not reach down to the stratified rocks, and are among those designated in a former chapter as drift-lakes. These shallow lake beds were doubtless left as such at the close of the Drift epoch, together with many others that the deepening of the valleys has drained and left no trace of them, while these remain because no accumulation of waters beyond them has sent sufficient current across them to cut a channel for their outlet and drainage. Although marshes

sometimes adjoin these lakes, they usually have well defined shores, so that they are in no manner objectionable features in an inhabited region. On the contrary, they often add great beauty to the otherwise monotonous surface, and are of much practical benefit to the inhabitants by furnishing a constant supply of pure water for their domestic animals. Their shallow borders are not unfrequently filled with a growth of wild rice, (*Zizania aquatica*) which affords abundant food for myriads of wild water-fowl that visit this region every autumn and spring.

The general character of the soil of these counties has been described with that of the others of the region in the first part of this chapter, but the valley of the Des Moines, from its entrance into Emmet county to its exit from Palo Alto, deserves especial mention for its beauty and fertility. Its character has been before referred to in the description of the rivers of the State, and it is, perhaps, sufficient to add here that it must ere long become one of the most desirable agricultural regions in Iowa.

As there are no exposures of rock in place within either of these two counties, the only stone to be obtained by the inhabitants for the necessary purposes of walling wells, cellars, and the foundations of buildings, is that which may be supplied by the boulders of the drift. In a few limited localities, these are sufficient for such purposes, but there are large portions of the counties upon which scarcely a boulder appears. Taking both counties together, so far from there being enough of them to prove an encumbrance upon the surface, as they are in some localities in the Eastern States and Canada, they are so few here that the ordinary wants of the future inhabitants, in the absence of more convenient material, will cause them to be so completely collected for economical use that they will finally disappear from the surface entirely,

Although these counties occupy some of the highest land in the State, there is no difficulty whatever in obtaining a good supply of the purest well water at as little depth as anywhere

else within its limits. All wells dug here will, of course, be in the drift alone, for water will always be obtained before reaching its base.

With the exception of a few groves of forest trees in the vicinity of the lakes and smaller streams, the woodland is confined to the comparatively narrow belts that border both banks of the Des Moines river. It is from these and the few peat marshes within their borders that the inhabitants of these two counties must obtain their supplies of fuel before a more constant and sufficient supply can be established by the growth of forest trees by artificial propagation. Knowing the capability of the soil for producing a thrifty and abundant growth of forest trees, a sufficient supply of fuel for the future inhabitants is not regarded as a matter of uncertainty.

5. POCAHONTAS COUNTY.

This county is the most southeasterly one of the twelve enumerated in this chapter. Like a large proportion of the counties in the State, it is perfectly square in outline and contains sixteen congressional townships, making it twenty-four miles across both from north to south and from east to west. Its superficial area is, consequently, five hundred and seventy-six square miles, or three hundred and sixty-eight thousand, six hundred and forty acres. Its northwestern corner barely reaches the Great Watershed, and its drainage is, consequently, wholly into the eastern system. This is effected to a greater extent by Lizard creek than by any other one stream, the remainder of the surface being drained by upper branches of Raccoon river, by the Des Moines river, which passes across the northeastern corner, and by small tributaries of the latter river.

The largest bodies of woodland in the county are in the valley of the Des Moines. These are necessarily limited by the smallness of the portion of that valley that lies within its limits. It will thus be seen that Pocahontas county is almost one uninterrupted prairie which extends also into all the

counties adjoining it. This prairie soil is the usual drift soil of the region, is very fertile and without objectionable qualities; and, having a gently undulating surface, it may be cultivated in the most convenient manner.

The want of fuel constitutes the great deficiency in the material resources of the county, but it has been often shown that this deficiency need be only temporary, because only a few years are necessary to effect the growth of an abundance of fuel from the soil in the shape of forest trees.

Pure water is obtained even upon the broadest and most elevated prairies at only a few feet beneath the surface, and the wants of the county for stock water are also well supplied by its numerous small rivulets and creeks.

The exposures of Sub-carboniferous limestone in township 92, range 31, which were referred to in the early part of this chapter, will, in the future, become very valuable from the fact that they may be made to supply large quantities of excellent lime besides much good material for common masonry. The value of these quarries will be greatly enhanced in consequence of the fact that they occupy the most northwesterly point at which a supply of lime-producing rock can be obtained, except that obtained from the chalky beds in the bluffs of the Big Sioux, a hundred miles further west. The county contains no other accessible stone besides this, except the scattered boulders of the drift, and these are so few that before it is completely settled, they will have been so fully collected for economic purposes that no evidence will remain upon the surface that the drift of this region ever contained any of them.

6. DICKINSON COUNTY.

Dickinson is one of the northern tier of counties, the third from the western boundary of the State, and the ninth westward from the Mississippi river. It lies directly upon the Great Watershed, and consequently is, without doubt, the most elevated county in Iowa, Its superficial area is the

same as that of Emmet, namely : four hundred and eight square miles, or two hundred and sixty-one thousand, one hundred and twenty acres.

It is drained almost entirely by the upper branches of the Little Sioux, which has its rise here, and into which Spirit and Okoboji lakes, two of the finest in Iowa, empty. The drainage of this county is not very distinctly marked, for it is more emphatically a summit region than any other part of the State; not only that it is really the most elevated, but its surface has evidently undergone less change by erosion since the Glacial epoch than any other in Iowa.

Spirit and Okoboji lakes are located in this county, the former lying within township 100, range 36, and the latter in ranges 36 and 37 of township 99. They are more fully described in a separate chapter of this report. Considerable bodies of woodland exist in the vicinity of these lakes and upon their borders, which together with the fertile and undulating surface of the surrounding region, the uniformly clean gravelly shores and clear water of the lakes render it one of the most delightful regions for summer residences in the State.

The general surface of this county is undulatory. That of the western and southern portions is of that undulating character which is common to the drift of the State in the vicinity of the streams, and has been principally caused by the deepening of the drainage depressions from the general level which the surface possessed at the close of the Drift or Glacial epoch. In such cases the inequalities of surface consist of gently elevated longitudinal ridges between corresponding depressions that constitute the drainage, and lead into each other by miniature systems, which in turn lead into a common stream. The deepening of these little depressions and valleys by the action of their own waters have obliterated the ponds and marshes and lakes that may have existed then as they now exist in other parts of the county, and also obscured the definiteness of any knobby elevations that may formerly have projected above that general surface level. In

the vicinity of these lakes, however, and for a distance of several miles around them, the "knobby" drift presents its peculiar characteristics. This is particularly the case in that part of the county which lies between the lakes and the upper branches of the Little Sioux, that traverse the western part of the county. That peculiar character of surface which the Drift Deposit presents in some parts of Northern Iowa and called "Knobby Drift," by Dr. Owen, is more fully described in the chapter on the Surface Features of the State. In this county, the knobs occur without any perceptible order or system of arrangement, being scattered promiscuously, sometimes occupying a large part of the surface in limited neighborhoods and sometimes almost isolated in a surrounding fertile and more level surface. Upon a few square miles of space immediately west of Spirit and north of Okoboji lakes, these gravelly knobs and the resulting inequalities of surface are conspicuous, and a number of small lakes rest in the depressions thus formed. Some of these depressions contain mere marshy ponds, but several of them hold very pretty little sheets of water. The height of these knobs from the ponds or the general surface will vary from twenty or thirty to fifty feet. The highest elevation of land that could be found in the vicinity of Spirit or of Okoboji lakes is the elevation between the two, which is about eighty feet above the level of the former, that lake being about six feet above the level of Okoboji lake.

The surface of Dickinson county is principally fertile and beautiful prairie, and although the knobby drift is as well shown here as in any other part of Northern Iowa, it must not be supposed that the knobs occupy any considerable part of the surface. Indeed, they would not be thought worthy of being so frequently referred to in this report, if it were not that their prevalence and barren character have been popularly greatly over estimated.

There are no exposures of stratified or other rocks in place within the limits of Dickinson county, but upon the shores of the two largest lakes there are frequently large

collections of drift boulders that have been gathered up from the bottom and thrust out upon or against the shore by the ice, in the manner explained in the chapter upon the Lakes of Iowa. These boulders are composed of the various kinds of rocks that occupy the surface in their original ledges in that portion of Minnesota which lies directly north of this part of Iowa. They are principally of granite and red quartzite with an occasional one of buff-colored, magnesian limestone. The first are the reddish-gray, homblendic, granite boulders, so common in all the drift of Iowa. The quartzite boulders are derived from the formation to which the distinctive name of Sioux quartzite has been given in the classification of the formations of Iowa in this report, and which is found in various parts of Minnesota as well as in Iowa. The magnesian limestone boulders are without doubt derived from the Lower Magnesian limestone formation, the strata of which are exposed to the northward of this region, in the valley of the Minnesota river. The boulders of this limestone are not numerous upon the shores of these lakes, but since no other limestone is to be found there, the inhabitants have occasionally collected them and burned them into lime. It will be readily understood that the presence here of these limestone boulders does not indicate the existence also of ledges of limestone any more than the presence of the granite boulders indicates the existence there of granite ledges.

The granite and quartzite boulders, although exceedingly hard and difficult to break into desirable forms for economic use, are nevertheless valuable material for such purposes when once prepared. It is rare that an acre of soil here contains a sufficient number of boulders to impede cultivation, but with those upon the shores of the lakes they are sufficient in quantity to serve the inhabitants of the county, both present and prospective, the ordinary purposes of walling wells, cellars, basements, etc.

Besides the streams and lakes of pure water, excellent supplies may also be obtained in all parts of the county

at only a few feet beneath the surface. This whole region is of course far beyond the limits of the coal-field, but although so much of its surface is prairie, it is nevertheless quite well supplied with fuel by the woodlands in the vicinity of the lakes and elsewhere.

7. O'BRIEN, CLAY, BUENA VISTA, AND CHEROKEE COUNTIES

These four counties, each containing sixteen congressional townships, and consequently square, lie so adjacent that they form a perfectly square area of forty-eight miles across from east to west, and the same from north to south. They consequently contain in the aggregate two thousand three hundred and four square miles, or one million four hundred and seventy-four thousand, five hundred and sixty acres. They are here grouped together for description, because they are so similar in all respects that much repetition would be unavoidable if each should receive a separate description. Only one tier of counties separates the square region thus formed from the north boundary of the State, and only one tier lies between it and the Big Sioux river, which there forms a part of the western State boundary.

Much the greater part of these counties is drained by the Little Sioux, a tributary of the Missouri river. The upper branches of Floyd river, another tributary of the Missouri, reach into the northwest corner of O'Brien county, and the upper branches of the Raccoon collect the waters of the southeastern corner of Buena Vista county, for the Mississippi drainage. It will thus be seen that the greater part of these four counties lies upon the Missouri drainage slope, the course of the Great Watershed, after passing down through the eastern part of Clay county, sweeps to the westward, and passes out of Buena Vista county, near its southwestern corner.

Buena Vista, the most southwesterly of these four counties, is almost entirely destitute of woodland; narrow belts in that

portion of the valley of the Little Sioux which traverses its northern border, and a few groves upon the head-waters of the Raccoon, in its southern part, constitute almost its entire supply. Its surface is thus an almost uninterrupted, gently undulating prairie, the greater part of it being unbroken by any valleys and constituting a part of the broad summit region of the Great Watershed. This broad space, unmarked as it is by any considerable valleys, is nevertheless sufficiently drained to render all but a very small part susceptible of immediate cultivation, and the greater part of the remainder may be reclaimed by artificial drainage. Upon this summit region are occasional marshes, and a number of small lakes, the largest of which is Storm lake, the largest in Northwestern Iowa, except Spirit and Okoboji lakes.

Clay, the most northeasterly of the four counties, is comparatively well drained by the Little Sioux, whose windings cause it to traverse a large part of its area. That portion of the country which is enclosed within the great bend of that river, comprising a large part of its eastern as well as the greater part of its western half, is occupied by one of the most level prairies of this part of the State, but fully one half of the county has the usual gently undulating prairie surface. The valley slopes of the streams are usually gentle, but those of the Little Sioux, in the southern part of the county are very abrupt, especially along that part of its course which has an east and west direction. Indeed, this portion of its valley is really a gorge cut by its own waters in ages past, transversely out of the deep Drift Deposit, which here constitutes the broad summit region of the Great Watershed, here having the appearance of a distinct general level. From this general prairie level down to the water in the stream at Peterson, the present county seat, the depth is one hundred and ninety feet. The width of the valley from brow to brow is here about a quarter of a mile and the sides are consequently steep, but upon the steep valley-sides no exposure of rock in place is to be seen; nothing but the drift,

with its occasional boulders any where appears to view either upon the valley-sides or upon the unbroken surfaces.

O'Brien, the northwestern of these four counties, is located upon one of those secondary summit spaces about the headwaters of the tributaries of the great rivers. Lying between the upper branches of the Little Sioux and Floyd rivers, which merely enter its borders, its surface is necessarily almost one unbroken prairie. Its drainage is effected by the upper branches before named, and by the very gentle depressions that lead into them from the central portions. The surface is gently undulating, and although it possesses no well marked valleys, marshes and ponds are comparatively rare. The southeast corner township of the county contains almost all the woodland within its limits, and this is confined to the immediate valley of the Little Sioux.

Cherokee county, the southwestern one of the four, is more completely drained, or rather it is more conspicuously marked by its valleys than either of the others. Little Sioux river enters its northeastern corner from *O'Brien* county, and traverses it in a southwesterly direction, passing a little east of its centre, and then makes its exit from the county a few miles east of its southwestern corner. The west fork of the Little Sioux reaches into and drains a part of the western tier of townships, while the Maple, another tributary of the Missouri river, by its upper branches drains the greater part of the eastern tier. The valley of the Little Sioux forms a marked feature in the surface of *Cherokee* county, and although its slopes are usually so gentle that the land may all be conveniently cultivated, it is nevertheless quite well defined, and the extensive views that the traveller occasionally gets of it are often quite interesting. In some places, indeed, the scenery is very beautiful in its kind, and the valley will at no distant day be one of the finest agricultural regions in the State.

There is of course no exposure of rocks in place in either of these four counties, for they lie in the heart of the great stoneless region of Northwestern Iowa. Boulders are by no

means abundant in either of them, but in some places they may be obtained in sufficient quantity to meet the wants of the inhabitants for common stone. These boulders are of the same kinds as those mentioned as prevailing in Dickinson county, and other parts; namely, granite, red-quartzite, and occasional masses of light buff-colored magnesian limestone—the latter being quite rare. The great want of these counties is fuel. It is hardly probable that any coal will ever be found in this part of the State, although it is not unlikely that small outliers of coal-measure strata may really exist here beneath the drift, and may possibly be discovered by artificial excavation in the southern parts of Buena Vista and Cherokee counties. Future supplies of fuel to meet the wants of an increasing population, must be obtained by planting trees which will surely yield a profitable return.

Water, pure and excellent, may be obtained everywhere at only a few feet beneath the surface. Two railroads are now projected through these counties from east to west, which will supply, to a great extent, by transportation, the deficiency in fuel and building materials. When these are completed, the full settlement of a region so inviting cannot be long delayed.

8. OSCEOLO AND LYON COUNTIES.

These two are the most northwesterly counties in the State; Lyon occupying the extreme corner and Osceolo lying immediately east of Lyon. Osceolo county contains four hundred and eight square miles, and Lyon about four hundred and ninety-seven, making an aggregate superficial area for both counties of three hundred and eighty-two thousand and eighty acres. The two counties form a long, narrow area of more than sixty miles from east to west, and only seventeen miles from north to south. These two counties are very similar in their general surface characters, being almost exclusively prairie, covered with a fertile loamy soil with

occasional gravelly spots. The latter, however, constitute only a small fraction of the entire surface.

Osceolo is drained by the upper branches of the Floyd and Little Sioux rivers, both of which take their rise within its limits; and although it thus occupies the position of a summit region in relation to its drainage, it is so well drained that very few ponds or marshes are to be found.

Lyon county is drained by Rock river and its branches, except a narrow space upon its western border which is drained by the Big Sioux. The whole surface is well drained by these streams, and yet it is very gently undulating; the valley-sides being without bluffs or steep places except those of the Big Sioux. The drift bluffs bordering the latter valley are frequently very steep, and reach a height of from one hundred to two hundred feet above the level of the stream.

These counties are almost destitute of woodland, even along the valleys of the streams which drain their surfaces, the principal exception being the narrow belt and groves that skirt the banks and bluffs of the Big Sioux. This, of course, is upon the western border of Lyon and leaves the remainder of that county, together with the whole of Osceola, a part of one immense prairie.

The only exposures of rock in place within the limits of these two counties that have yet been discovered, are those of the Sioux Quartzite located in the extreme northwest corner of Lyon. This is the only locality at which that formation is found exposed in Iowa, although it is well and abundantly exposed in the adjacent parts of Dakota and Minnesota. As one goes northward from the exposures of Cretaceous strata in the bluffs of the Big Sioux, in Plymouth county, he finds no exposures of strata of any kind until he reaches those of the Sioux Quartzite just mentioned. Although the Cretaceous strata are not actually exposed in Iowa at any point north of Plymouth county, there are many indications of its presence there immediately beneath the drift; and also that in the northwestern corner of Lyon county they rest directly upon the Sioux Quartzite. In other words, the strata of

Mesozoic age are understood to rest directly upon those of Azoic age, all palæozoic strata being absent. This view has also the additional evidence of the equivalents of those Cretaceous strata being found in Minnesota and Dakota, resting upon the same quartzite as well as upon granite rocks in place also.

The exposures of quartzite in Lyon county are all confined within the limits of one or two square miles, and chiefly upon the few acres of the angle formed by the northern and western boundaries of the State. They are here exposed in the bed and banks of the Big Sioux, showing a thickness of about fifty feet at their greatest exposure; but the formation is known to be at least three hundred feet thick only, eight or ten miles distant within the Territory of Dakota.

From these Iowa exposures almost any desired quantity of rock may be obtained for building and other economical purposes; but when the pieces that have already been loosened by fracture have been removed it will be somewhat difficult to quarry the rock, on account of its extreme hardness. This hardness is so great as to make it almost impracticable to dress blocks of it into desirable shapes for caps, sills, etc., for buildings; and the tendency it has to crack into comparatively small angular masses, renders it difficult to obtain pieces of suitable size for such purposes. It is suitable, however, for all the uses to which common, rough stone is applied, and has the advantage of being absolutely indestructible, so that when once used it will never yield to the action of the elements. The area upon which these quartzite ledges are exposed is so small, and so far removed from a large part of these two counties, that it is practicable for only a very small portion of them to be supplied with stone from this source. All other parts must depend solely upon the few scattered boulders, found principally in the valleys of the larger streams, or upon distant supplies by means of transportation.

These two counties, like the others of Northwestern Iowa, containing a purely drift soil, are well watered by its streams

and rivulets, and also by water which may be reached by digging only a few feet beneath the surface. The prairie creeks and rivulets here, as well as in other parts of the region, often consist in summer of series of isolated pools of comparatively pure water, although no current passes through them at such times. They are inhabited by the usual small species of fish, for the water does not disappear from them even in the driest times. Consequently, they serve an excellent purpose to the settlers for watering their stock. The soil has been before described as excellent, and the surface is so gently undulating that almost every acre of it may be conveniently cultivated.

9. SIOUX AND PLYMOUTH COUNTIES.

These two counties occupy positions, respectively, in the second and third tiers from the northern boundary of the State. The Big Sioux river forms the western boundary of each as well as a portion of the western boundary of the State. They are nearly equal in size and contain together about one thousand six hundred and forty-two square miles; or one million and fifty thousand eight hundred and eighty acres, almost every acre of which is fertile and tillable except what is actually occupied by the streams. They are, however, like all the counties of Northwestern Iowa, but poorly supplied with fuel and stone. Almost the only woodland within their limits exists in the form of narrow, interrupted belts, bordering the banks of the Big Sioux and the lower portions of the valleys of Rock and Floyd rivers.

The general surface of these counties is the same gently undulating prairie so often described before, the valleys having gently sloping sides, and except that of the Big Sioux, have no bluffs worthy of the name upon their borders. The bluffs of the Big Sioux, however, form a very conspicuous feature of its valley, are often as steep as the incoherent drift will stand, and reach a height from the water to the general level of the uplands of from one to two hundred feet. They

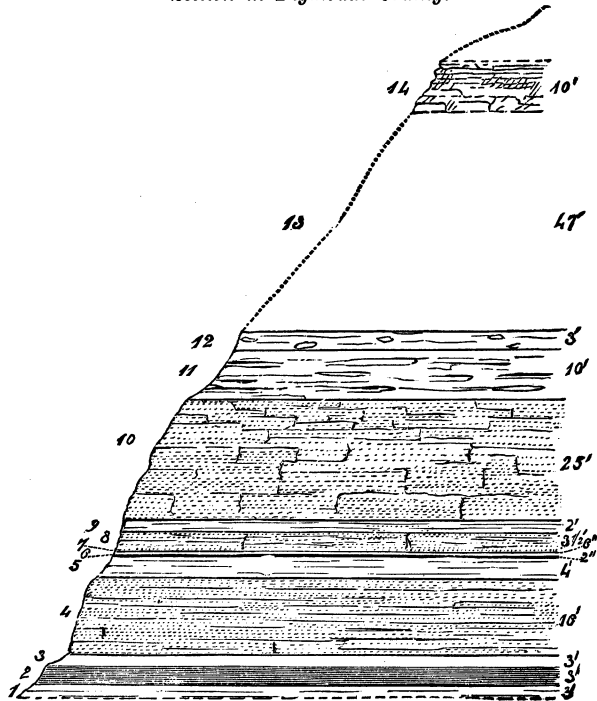
are, in almost all cases, destitute of trees except at their base, and even there they are as often absent as present. Although the scenery of the valleys of the Floyd and Rock rivers lacks the diversity possessed by that of the Big Sioux, they are destined to become delightful agricultural regions; and yet, the fertility of the valleys is scarcely greater than the average of the whole surface between them.

The greatest want of these counties is fuel and building material. It is not probable that any coal worth mentioning will ever be found in either of them, but it has before been shown that the scarcity of wood-fuel need be only a temporary one, for the soil will as certainly produce an abundant crop of wood as one of corn.

Not a single rock is to be found in Sioux county; and the only ones that Plymouth county contains are of the friable

FIG. 90.

Section in Plymouth County.



Cretaceous strata, almost all of which material is entirely unfit for building purposes. The chalky layers, however, may be burned into a fair article of lime. Drift clays are not so abundant in this part of the State as they are in the eastern and southern portions, but there are occasional localities where suitable materials for brick may be obtained, quite sufficient in quantity for all the wants of future inhabitants. It is only in the bluffs of the Big Sioux, a few miles both above and below the mouth of Broken Kettle creek, that the Cretaceous strata before referred to are found. No other exposures of strata of any kind are found in the remainder of the county, and no other stone is to be obtained, except the few scattered boulders that are occasionally met with.

The most important of these exposures are found on section 30, township 91, range 48; the foregoing is a diagram (Fig. 90) and the following is a description of the same:

No. 14.	Light gray, chalky limestone, in thin, shaly layers.....	10	feet.
No. 13.	Unexposed.....	47	feet.
No. 12.	Yellowish, shaly layers, with large septaria-like concretions.....	3	feet.
No. 11.	Ferruginous, shaly layers, containing some bluish clay..	10	feet.
No. 10.	Soft, gray and yellow laminated sandstones.	25	feet.
No. 9.	Blue and grayish, slightly gritty, shaly clay.....	2	feet.
No. 8.	Soft, yellow, laminated sandstone	3½	feet.
No. 7.	Blue clay.....	½	foot.
No. 6.	Brown, impure coal, irregular in thickness.....	1-6	foot.
No. 5.	Bluish gray clay	4	feet.
No. 4.	Soft, yellowish gray laminated sandstone.	16	feet.
No. 3.	Unexposed	3	feet.
No. 2.	Bluish black clays, apparently carbonaceous.....	3	feet.
No. 1.	Grayish clays	3	feet.
Total.....		130½	feet.

The base of this section is the level of the water in the Big Sioux river, the exposures being in the bluff valley-side. Resting upon No. 14, are probably a few feet in thickness of other layers of chalky material, since such debris is seen above the undisturbed strata, but resting upon that is the

Bluff Deposit and traces of the drift beneath it ; the whole height here, from the water to the highest surface immediately adjacent, is two hundred and ten feet.

The only beds exposed here, that are of any value as building material, are the chalky limestone of No. 14, which is only fit for lime, and the sandstone of No. 3, the greater part of which is too soft for any profitable use, but a part may be used for common masonry. The thin seam of coaly matter found here has given rise to hopes among the inhabitants that coal in paying quantities might be found. It has been shown elsewhere in this report that the facts ascertained during the labors of the Survey, taken in connection with universally recognized principles of geology, do not favor the prospect that such hopes will ever be realized. The soil, with the exception of that of the southwestern portion of Plymouth, which is in part occupied by the Bluff Deposit, is the usual fertile drift soil of Northwestern Iowa. It is capable of supporting a dense population in the greatest abundance, both of food and fuel, and the time is close at hand when these two counties will become occupied by a wealthy and numerous population.



Mills & Co. Lith. Des Moines.

VIEW LOOKING NORTHWESTWARD UP THE BIG SIOUX, 7 MILES NORTH OF SIOUX CITY.

1868

CHAPTER III.

MIDDLE REGION OF NORTHERN IOWA.*

1. GENERAL DESCRIPTION.

The following named eight counties are included under the designation which heads this chapter: Franklin, Wright, Cerro Gordo, Hancock, Worth, Winnebago, Kossuth,† and Humboldt. If it were not that Humboldt, the most south-westerly of these counties, is only three townships wide from north to south, the whole area would be perfectly quadrangular, and seventy-two miles wide from east to west, and sixty-five miles across from north to south. As it is, all the boundary lines are straight lines, and all the angles right angles, both of the whole region, and of its respective counties. Deducting four full congressional townships, on account of the smaller size of Humboldt county, as compared with the two which lie directly to the east of it, the whole area contains four thousand five hundred and thirty-six square miles; or two millions, nine hundred and three thousand and forty acres.

This area contains the principal peat region of Iowa, the peat occupying the numerous ponds and marshes that exist about the sources of the various streams that have their rise

*These counties have been only partially examined for want of time before the present report must be submitted to the legislature.

† Since this chapter was written, the legislature authorized the separation of the northern portion from the remainder of Kossuth county, under the name of Crocker county. Hence the last named county appears upon the maps of this report, but not in this chapter,

here. The principal portion of it lies upon and between the drainages of the Des Moines and Cedar rivers, and a glance at the map will show that as regards its drainage, this part of it is eminently a summit region, because many streams have their rise within it and flow out of it in all directions. Among these are the following ; namely, the Blue Earth, a tributary of the Minnesota, the East fork of the Des Moines, the Boone, Iowa, and also half a dozen larger or smaller tributaries of the Cedar, which together drain the whole western side of the region. In Kossuth county we find the unusual occurrence of two streams having a common source whose courses are in opposite directions. These are the Blue Earth and the East fork of the Des Moines; the waters of the former reaching the Mississippi by flowing northward into the Minnesota river, which empties near St. Paul, and those of the latter reaching the same river just below Keokuk, the mouths of each being more than three hundred miles apart. This place of common origin is called by the inhabitants "Union Slough," from this circumstance. It is a longitudinal depression in the general prairie level, having much the appearance of the valley of an ordinary prairie creek, except that its bottom is generally quite flat, without the usual small channel for drainage, and a large part of it is covered with peat. Its relation to the drainage of the State has already been described under the head of "Rivers and their Valleys."

The stratified rocks which occupy this region immediately beneath the drift, are doubtless of both Sub-carboniferous and Devonian ages, although no exposures of any kind occur in more than one-half of the whole region. This is inferred from the northwesterly and southeasterly trend of the formations of those systems where they are exposed in this and other parts of the State, and the fact that strata of these respective ages are exposed in both the northeast and southwest corners of the region. Neither Kossuth, nor either of the three central counties of the region which range through its middle from north to south, so far as is

now known, contains a single exposure of rocks in place. In Humboldt county, the most southwesterly of them all, there are a few exposures of the Kinderhook formation, limited coal-measure outliers, in and near the banks of the Des Moines river. Going eastward from that region, we find strata of the same age in the southern part of Franklin county, although none are found in Wright county which intervenes. The exposures of Sub-carboniferous strata in Franklin county occur in its southwest corner, appearing in the banks of the Iowa and in the valley of Beaver creek, in the southeast portion. Also in the valley of a creek near Hampton, in the middle portion, and a few small exposures near its northeastern corner. In short, all the strata thus far examined in this county are of Sub-carboniferous age, and all those of Humboldt are their equivalents. It thus appears that there is almost no westerly dip at all of the strata, from the eastern portion of Franklin county to the eastern part of Pocahontas county. This is well shown by the lithographed section accompanying this report.

Much the greater part of the surface of this region is prairie, but some woodland exists in the valleys of the larger streams, particularly those of the Shellrock and its branches. The broader prairies not being yet occupied, the principal part of the inhabitants are in the vicinity of the streams, and thus have convenient access to the woodland for their fuel. This is quite sufficient in amount to supply the wants of the present inhabitants, but it is wholly inadequate to meet the wants of a population so great as the soil is capable of supplying in plenty. Fortunately, a crop of forest trees may be as easily and certainly grown upon the soil by every farmer as a crop of corn, the only difficulty being the greater time that must elapse before a return can be received for the money invested.

Besides the present supplies of fuel in this region in the shape of forest trees, and the certainty that further supplies of the same kind may be obtained by cultivation, it has an

additional advantage over many other prairie regions of Iowa in its abundant supplies of peat. It is not claimed that peat has any advantage over either wood or coal as fuel, but for all domestic purposes it is scarcely inferior to either for those who have become accustomed to its use. In such a region as this which lies wholly outside of the limits of the coal-field, and where wood is scarce, its large deposits of peat possess a local value much greater than the same kind of fuel would have in regions where both wood and coal are plentiful. This local value is made more apparent in the region under discussion in view of the capabilities of the soil for supporting a dense population, the excellence of its water and healthfulness of its climate, making it certain that the present tide of emigration to the State will demand its broad prairies for cultivation, sooner than an adequate supply of fuel can be established by artificial planting of forest trees. All our indigenous forest trees, as has been often repeated, will grow with wonderful rapidity, but the settlement of the State is progressing more rapidly now than ever before, and the peat will serve a good purpose for fuel until wood can be grown, if no longer. For a more detailed account of the peat of this and other parts of the State, the reader is referred to the chapter devoted to that subject in another part of this report.

Lumps of coal and coal-like substances have not unfrequently been found in the drift of different parts of this region as well as further westward. They are usually discovered in the banks of streams or in artificial excavations, and are in separate, somewhat rounded lumps, usually small, but not unfrequently several pounds in weight. Their discovery leads to the popular belief that a regular bed of coal exists in the immediate vicinity, and that these pieces have been derived from it. A careful examination of this coal shows it to possess different physical properties from that of the Iowa coal-field, although much of it is found to be quite combustible. We have conclusive proof that the Iowa coal-field does not extend so far northward as this region,

although it is probable that limited outliers of it exist in Wright and Franklin counties, as they are known to in Humboldt. Therefore, all such specimens of coal found in the drift of this region, or at least those found to the northward of the counties last named, cannot have originated in the Iowa coal formations or their equivalent strata, and we must look elsewhere for the place of their original deposit. Going northward and northwestward from this region, we find in the Cretaceous strata of Minnesota a thin seam of impure coal like that of the lumps found in the drift of Northern Iowa, and which are identical also with that found in a similar seam in the Cretaceous strata of Plymouth county. Enough is also known of the strata that underlie this region to give the assurance that no bed of coal exists among them, and therefore, these drift lumps must have had a foreign origin and have reached their present positions by transportation from their original beds. The only way known to us by which they could have reached their present positions is, that by which a large part of the drift itself, including its boulders, was transported from the northward; namely, by glacial action. Therefore, we infer that these lumps of impure coal were brought from the coaly seam in the Cretaceous strata of Minnesota by the same means and at the same time the boulders were brought.

There is a possibility that some limited and comparatively unimportant deposits of coal may be found in outliers of the true coal-field that probably exist in the southern counties of this region, but examinations thus far made do not afford any evidence that a profitable bed of coal will ever be found within its limits. Therefore, the inhabitants of this region must depend for their supplies of fuel upon its forest trees of present and prospective growth; upon its peat, and upon such other fuel as may be brought from sources beyond its limits by means of its lines of public transportation.

The building materials of this part of the State consist of common and magnesian limestone, brick clays, and timber.

Brick clay is not so abundant here as it is farther southward; but sufficient supplies for all needed purposes may be obtained in almost every neighborhood of Northern Iowa. The common limestone produces good lime, besides serving an excellent purpose for common masonry. The magnesian layers are often sufficiently uniform to be dressed into the desired forms for use in buildings, and also for heavy masonry, such as bridge piers, etc. It has before been shown that Wright, Hancock, Winnebago, and Kossuth counties are destitute of any exposures of rock in place. Therefore all the stone these last named counties contain, is in the form of scattered drift boulders. These, in a region where other stone is abundant, would be rejected on account of the difficulty of breaking them into desirable shapes and sizes, but yet this is practicable, and their extraordinary durability will repay a part of the extra labor.

Aside from the materials hitherto enumerated, the mineral resources of these eight counties probably amounts to nothing of any practical value. At least no indication of the existence of any other mineral substances in sufficient quantity to be of real value have been observed. The soil of this region is, of course, that of the drift, and its general character of that of the ordinary fertile prairies with a slightly greater proportion of sand in its composition, and a correspondingly less proportion of clay in it than there is in that of southern Iowa. It is true, there are some barren drift knobs and some marshes in the region, but even where these most prevail they form only slight exceptions to the general fertility. The knobs are mostly small rounded elevations of gravelly drift, usually only a few feet in height above the general surface. Sometimes, however, they constitute hills of considerable height. One of these, in the extreme northeast corner of Hancock county, called "Pilot Knob" by the inhabitants, is a very conspicuous object for several miles around. Its actual height above the level of Lime creek, which lies a couple of miles to the southward of it, was not measured, and it is very difficult to estimate correctly the

height of such an object in such an open county; but it is thought to be about three hundred feet above the water in the creek, and apparently a hundred feet higher than any of the other knobs in the neighborhood. This knob, together with the others of the vicinity, constitute a part of the extensive traces of a slight ridge mentioned in the early part of this report as probably the remains of a glacial moraine.

Aside from these knobs, properly so called, as one travels over the region, there being very little to obstruct distant ranges of vision, he sees in the far distance low longitudinal ranges of elevated surface, slightly knobby in its outline, and forming the watersheds between the streams. Although they often appear quite distinct in outline as seen at a distance, upon near approach their slopes are found to be as gentle as an ordinary prairie, which they really are, their entire surfaces being fertile to their tops. In the western and central parts of this region the drift is usually very thick. Sometimes there are evidences that it reaches nearly or quite two hundred feet in thickness. This is suggested by the great depth to which some of the valleys have been eroded without exposing any of the underlying strata, and by the great extent of surface beneath which those rocks are entirely hidden. Approaching the eastern part of the region, we begin to see evidences that the drift is much thinner there, and the stratified rocks are seen exposed in all the tributaries of the Shellrock and Cedar. It is shown elsewhere that this great variation of the thickness of the Drift Deposit, occurs also in other parts of the State.

2. FRANKLIN COUNTY.

Boundaries and Area. Franklin county is one of the third tier from the northern boundary of the State, and its western border lies about midway between the Mississippi and Missouri rivers. It is one of the numerous counties of the State whose outline is a perfect square. It contains sixteen full congressional townships, and its superficial area is consequently five hundred and seventy-six square miles; or three

hundred and sixty-eight thousand, six hundred and forty acres.

Drainage and Surface Characters. The watershed which divides the drainage of the Iowa and Cedar rivers passes through the southwestern part of this county, leaving much the largest portion of it to be drained into the Cedar. This is accomplished, principally, by the West Fork of the Cedar and by Otter, Main's, and Beaver creeks; Otter and the West Fork being the largest, and each affording considerable water-power by rocky obstructions to their flow. The valleys are usually broad and shallow, their sides being insensibly lost in the undulations of the general surface. This general surface is the ordinary undulating or rolling prairie, extending over the whole country between the streams, the borders of which have usually a narrow belt of woodland; and in the valleys of the West Fork and Otter creek there are large bodies.

Geology. The limestone of the Kinderhook beds—Sub-carboniferous—is found exposed to a greater or less extent in the valleys of all the creeks and streams of the county before mentioned. They appear as ledges along the immediate banks of the Iowa river, and as more bold exposures in the valley of Otter creek near Hampton, but in other places they are found at the surface upon gentle slopes in consequence of the thinness of the Drift Deposit. In the extreme northeast corner of the county they appear thus at a few points at some distance from the streams and upon elevated surfaces.

Material Resources. The soil of this county is generally good, even for Iowa, the only exceptions are a very few small, gravelly knobs and a few marshes; and these are very small compared with the whole surface. This soil, like all other soil of Iowa, is capable not only of producing abundant farm crops but it may be made to supply all deficiencies of fuel that now exist, by the growth of forest trees. It has before been shown that there is no ground for reasonable hope that any profitable deposits of coal, if even a trace of it will ever be found in Franklin county. There are, however, some

important deposits of peat in the county which together with the woodland, before mentioned, constitute its present sources of supply for fuel. The following are some of the localities in which peat has been observed; namely, near the north line of township 90, range 19; on section 25, township 92, range 20; and in "Beaver Slough," in township 90, range 21. There are, doubtless, other peat marshes besides, but the whole county has not been examined for that purpose. Enough is known, however, to indicate that it is not one of the principal peat counties, although it adjoins the region where peat is most abundant.

Franklin county is supplied with sufficient stone for all common purposes, much of which serves a good purpose for building material. Very little of it is fit for lime, but this indispensable material is abundant in the adjoining counties of Hardin and Butler. The streams and creeks of Franklin county have usually clear water, and these, together with numerous springs supply the inhabitants well for ordinary purposes. Good wells may also be obtained at moderate depth and with little labor in all parts of the county, except upon some of the higher portions of the northeast quarter. Here it is occasionally, but rarely necessary to drill through the strata which come near the surface there, to obtain water. Even in these cases it has been found at comparatively slight depth.

3. WRIGHT COUNTY.

Boundaries and Area. Wright is one of the third tier of counties from the northern State boundary and lies about mid-way between the two great rivers. It is bounded on the north, east, and south respectively by Hancock, Franklin, and Hamilton, and on the west by Humboldt and Webster. Like Franklin, its outline is a perfect square and its superficial area five hundred and seventy-six square miles; or, three hundred and sixty-eight thousand, six hundred and forty acres.

Drainage and Surface Characters. The watershed between

the Iowa and Boone rivers passes from north to south nearly centrally through the county, the first named river passing through the eastern tier of townships and the other through the western tier. Thus the two principal, and almost the only streams within its limits, are near its eastern and western borders respectively. Not only the central portion between these two rivers, but even the whole county has a general level almost approaching flatness. Nevertheless, neither the prairies of this county nor of any part of northern Iowa are so flat as those of some parts of southeastern Iowa, or some parts of Illinois, but are everywhere gently undulating even at the greatest distances from the valleys. Both the Boone and Iowa are very small streams in this county; but their valleys present considerable diversity of scenery and even a good degree of beauty, especially as compared with the usual monotony of prairie surface of the greater part of the county. The real watershed between these two rivers passes a little east of the centre, and a little nearer to the Iowa than to the Boone. The general surface being so nearly level, its existence is detected only by an indistinct line of slightly "knobby" elevations, occupying a strip of country a few miles in width, running entirely through the county from north to south. These undulatory elevations, of course, necessitate corresponding slight depressions in quite a number of which rest beautiful little lakelets; but they are oftener marshy and sometimes contain peat. Lakes Gertrude, Cornelia, and Elm are among the pleasantest of these little sheets of water; but Walled lake has become most noted on account of the popularly supposed human origin of its so-called walls. As a lake, it is not a very interesting object; being very shallow it is grown so full of rushes in summer that little can be seen of its water. A full description of this and other lakes, together with an explanation of the origin of the so-called walls, will be found in a previous chapter of this report.

Although the valleys of the Boone and Iowa reach a depth of near a hundred feet from the general level, no exposures of

strata have yet been observed in either of them or elsewhere within the limits of the county. The supplies of stone in Wright county are, therefore, confined to the few boulders found in the drift. These are very scarce, however, and consequently building material of this kind must be obtained elsewhere. As there is no reason to hope that supplies of coal will ever be found in Wright county, the inhabitants must depend for their fuel upon the moderate deposits of peat and the present limited supplies of forest trees, and upon their prospective growth for future supplies. It possesses some advantage, however, in the close proximity of the coal-field to the southward. As to the material resources of Wright county, the subject may be summed up in the statement that they consist mainly in the great and general fertility of its soil. It constitutes an excellent agricultural and grazing region, for which it is well adapted by the plentiful supplies of water in its streams and at only a few feet beneath its surface.

4. HUMBOLDT COUNTY.

Boundaries and Area. This county has four congressional townships less than the two counties just described, and which lie directly to the eastward of it. On the north and south, it is bounded respectively by Kossuth and Webster counties both of which are larger than this, and on the east and west respectively, it is bounded by Wright and Pocahontas counties. It contains only twelve townships, and its superficial area is, therefore, four hundred and thirty-two square miles; or, two hundred and seventy-six thousand, four hundred and eighty acres.

Drainage and Surface Characters. Humboldt county is drained mainly by the two principal branches of the Des Moines river, which have their confluence within it and near its southern boundary. These two branches are designated respectively by the inhabitants, the East and West Forks. The East Fork passes down nearly centrally through the

county, from north to south, while the West Fork, entering it from the northwest, divides its western half into nearly equal parts. Boone river cuts across its extreme northeastern part, but drains only a very small portion of its area. By the streams just named, together with their tributaries, the county is very effectually drained. There is, however, a considerable area in its eastern part, near Owl lake, that is not sufficiently drained to be tillable. This marshy area contains several square miles, and in wet seasons it is, in a great degree, covered with water, yet the water does not remain upon it during the whole year, and is not so deep as to prevent an abundant growth of coarse, rank grass upon nearly its whole surface. This grassy marsh, or series of marshes, although containing several thousand acres, is but a small fraction of the surface of the county, and there is no doubt that as soon as land shall reach a price that will warrant the outlay, the whole of it may be drained so completely, and at moderate cost, that it will be among the most productive farming land in the county.

The valleys of the principal streams are interesting and fertile regions. Their sides usually slope gently to the uplands and are lost in the gentle undulations of the general surface. The soil is the usual warm, mellow, drift soil of Northern Iowa and is everywhere fertile and tillable, with slight exceptions such as have before been named. Much the greater part of the surface is prairie; indeed, the only exception is the woodland of the valleys and valley-sides of the larger streams.

Geology. Considerable exposures of the limestone of the Kinderhook beds (Sub-carboniferous) occur in the banks of both forks of the Des Moines, near the center of the county. One of these localities is a little above the town of Dakota, another at the town of Springvale, and still another about five miles above the latter town. The two first named localities are less than two miles apart, and are respectively in the valleys of the East and West Forks. At Springvale, the strata reach a visible thickness of some twelve or fifteen feet and

are seen along a distance of about half a mile in the banks of the stream. They consist almost entirely of distinctly oolitic limestone. The following named strata appear at the locality above Dakota:

No. 4. Fragmentary, gray limestone	1 foot.
No. 3. Indurated, sandy clay.....	2 feet.
No. 2. Calcareous sandstone, in thin layers	6 feet.
No. 1. Uniformly bedded, magnesian limestone	4 feet.
Total.....	13 feet.

No. 1 was partly hidden by the water of the stream, and if the mill-dam just below should be raised it would still farther cover it. It contains some of the best building stone in all that region. At Springvale, stone may be procured in much greater quantity. It is there suitable for all ordinary purposes, and also for lime. At the exposures farther up the West Fork, the stone is also excellent for lime and suitable for all the purposes to which ordinary stone is applied.

It will be seen that although a large part of Humboldt county is destitute of stone, it is still far better supplied with that valuable material than any of the counties of Northwestern Iowa.

So far as this county has been examined, no indications were observed that would lead to the belief that the coal-bearing strata extends so far north as this county, except as disconnected patches or outliers, such as is found near Springvale. Even should more such outliers of coal-measure strata exist in Humboldt county, and coal be found in them, there is thought to be very little probability that coal in profitable quantity will be found in such slight deposits of its strata and so far removed from the recognized unbroken border of the coal-field. Therefore, it is believed that this county must depend for its fuel upon its present and future growth of forest trees, its peat, which exists in limited quantities in the eastern part, and upon coal brought from beyond its limits to the southward.

5. KOSSUTH COUNTY.

Boundaries and Area. Kossuth, as at present organized, is the largest county in Iowa. It is forty-one miles long from north to south, and twenty-four miles wide from east to west; and being rectangular in outline, it contains nine hundred and eighty-four square miles; or, six hundred and twenty-nine thousand, seven hundred and sixty acres. It extends southward from the northern State boundary as far as the southern line of the second tier. Formerly, indeed, its southern part was one county of the second tier, while its northern twelve townships constituted another of the first tier under the name of Bancroft. Subsequently, the organization of the latter was abandoned and its territory attached to Kossuth.*

Drainage and Surface Characters. This county is drained principally by the East Fork of the Des Moines, which has its rise in the northern part, and traverses it nearly in a southerly direction. Union Slough, as explained in another chapter, is the common source both of this fork of the Des Moines and of the Blue Earth. It will thus be seen that Kossuth county occupies the summit between the drainage southward into the Des Moines, and northward into the Minnesota. Although it occupies such a summit position, similar to those upon which the greater part of the lakes of Northern Iowa rest, it is nevertheless free from lakes, and even marshes are by no means numerous. A part of the latter are peat marshes, but these are mostly confined to the northern half of the county, and are more definitely referred to in the chapter on Peat in another part of this report. Besides that the pond-like marshes so common in Northern Iowa, Union Slough contains several hundred acres of peat.

The general character of the surface of Kossuth county is that of a gently undulating prairie. Near its northern border the undulations partake of the character that has been aptly termed "knobby," by Dr. Owen. Very few of

* Since this chapter was written, Kossuth county has been again divided; the northern half taking the name of Crocker, and the southern retaining the name of Kossuth.

these knobs are gravelly or barren, and all are covered by a growth of prairie grasses.

Geology. No strata of any kind are known to be exposed within the limits of Kossuth county, but judging from the known trend of the formations of the State, it is believed that the strata next beneath the drift belong to the Sub-carboniferous group. It is not probable, however, that this will ever be accurately known on account of the great depth of the drift in this part of the State. Drift boulders are comparatively rare in this county, and gravel seldom appears.

Material Resources. The soil of Kossuth county is very fertile, and in view of the fact that almost every acre of it is tillable, the magnitude of this source of wealth for its future inhabitants is in no danger of being over-estimated. For building materials, brick-clays may be obtained in sufficient quantity in its valleys, and a moderate amount of timber also in the vicinity of its streams.

Since no reasonable hope can be entertained of a future discovery of coal, its inhabitants must rely upon its peat, and its present and prospective growth of forest trees for fuel.

Even although Kossuth county occupies so elevated a position, there is no difficulty in obtaining water of excellent quality at only a few feet beneath the surface at almost any point that may be chosen.

4. WINNEBAGO AND HANCOCK COUNTIES.

Boundaries and Area. These two counties lie directly east of, and adjoining Kossuth, their position being almost exactly central between the two great rivers, and both together form an area of exactly the same shape and size as that county alone. Winnebago is one of the northern tier of counties, and contains four hundred and eight square miles; and Hancock, immediately south of it, contains five hundred and seventy-six square miles. Their importance as an agricultural region will be apparent by the statement that they

contain six hundred and twenty-nine thousand, seven hundred and sixty acres.

Drainage and Surface Characters. These two counties are taken together for description on account of their great similarity in all respects. In relation to the drainage of these and the surrounding counties, they possess the characters of a flat summit-region in a more marked manner than any other region of the State, for it is less completely drained than any other. Notwithstanding this fact, there is only a comparatively small portion of the whole surface that is not now tillable. No streams of any considerable size traverse either of these counties, but quite a number of such have their rise here. Upper branches of the Shellrock, Iowa, Boone, Des Moines, and Blue Earth rivers rise within the limits of either Hancock or Winnebago. The most deeply eroded valley is that of Lime creek, which is also the largest stream. It traverses the eastern part of Winnebago, and cuts across the northeast corner of Hancock. The undulatory, and sometimes knobby character of the surface near this valley, renders it difficult to estimate its average depth from the general surface, but it is probably not more than a hundred feet, yet some of the knobs in the vicinity are nearly or quite double that height.

The next deepest valleys from the general surface are those of the Boone and Iowa rivers, which, although they have their rise here, reach a depth of between fifty and a hundred feet at the southern line of Hancock. These two streams together with their branches drain the southern part of that county pretty well, which together with the eastern part of Winnebago are the best drained parts of the two counties. A large number of marshes and some open ponds exist in the other parts, but many of the marshes are capable of being drained and reclaimed to cultivation. A great proportion of the marshes are, however, filled with peat and are described quite fully in the chapter on Peat in another part of this report.

Nearly the whole surface of these counties is prairie, and

taken, as a whole, it is more nearly flat than any other part of Northern Iowa, yet in its flattest portion the surface is slightly undulatory.

Geology. No exposures of stratified rocks have yet been found in either of these counties, but if any should ever be reached by artificial excavation, or hereafter be exposed by the erosion of the streams, they would probably be found to be of Devonian age, except perhaps in the southwestern corner of Hancock, where the Sub-carboniferous strata probably exist immediately beneath the Drift. The Drift of these two counties is evidently very thick, but as its base is nowhere seen its full thickness cannot be determined at any point. In the counties to the eastward of these it rapidly becomes thinner.

Material Resources. Notwithstanding the existence of the marshes and knobs, before referred to, the proportion of untillable land in these two counties is very small, and in any less fertile country than Iowa would hardly be noticed. The soil is generally of a fine, loamy character, well suited to the production of all crops to which the climate is adapted. Therefore, the material resources of Hancock and Winnebago counties consist almost entirely in their fertile soil. The only stone accessible within their limits are the drift boulders, and these are not by any means plentiful. Where they are found they serve a very good purpose for the foundations of buildings, etc. Including peat, these two counties are well supplied with fuel, but woodland being in so small proportion to the surface, that kind of fuel will be insufficient alone to meet the wants of the rapidly increasing population, unless forest trees are extensively planted.

7. WORTH AND CERRO-GORDO COUNTIES.

Boundaries and Area. These two counties are also so similar in their physical and geological characters that they are placed together for description. Together they form an area of the same size and shape as that of Winnebago and Hancock together. They lie respectively east of Winnebago

and Hancock, Worth being one of the northern tier of counties. The superficial area of both together is about six hundred and twenty-nine thousand, seven hundred and sixty acres.

Drainage and Surface Characters. Both these counties are drained entirely by tributaries of Cedar river, all of which flow from them in a southeasterly direction. The Shellrock is the largest of these and together with its principal branch has its rise in Minnesota, just beyond the northern boundary of Iowa. All their other streams rise within their own borders. As a whole, both these counties are well drained, notwithstanding the fact that they are two of the most important peat counties in the State, and the water of their streams is generally clear and pure. The greater part of the surface of both counties is occupied by the usual gently undulating prairie, the undulations being increased near the streams so that their valleys have not the well defined borders that those of Southern Iowa generally possess. Although limestone strata are frequently exposed in the valleys of their streams, they are not often seen in the form of bold bluffs as they are farther southward and eastward. The Drift Deposit being comparatively thin, especially in their eastern portions, most of their creeks and streams have eroded their valleys through it so that their waters flow upon the exposed strata, along a large part of their courses instead of upon the loose drift alone, as is the case with the greater part of the small streams of Iowa. If a line be drawn from north to south, dividing these two counties each into two equal parts, the eastern half of each will be found to possess many characters in common that are not well marked in the western halves. Thus we find stratified rocks plentifully exposed in the eastern halves, and almost none at all west of a line so dividing the counties. The eastern halves also contain the greater part of the woodland, and the western halves the greater part of the peat. It is easy to see that this distribution of the materials named is due to the physical characteristics of each section. There is a very

pleasing diversity of surface in the eastern portions of these counties produced by the valleys of the numerous creeks and streams, and even the prairie portions are not devoid of a good degree of diversity occasioned by their undulations.

Clear lake, a sheet of water containing some eight or ten square miles, is probably the most striking natural feature. It is located in the western part of Cerro Gordo county, and is more especially referred to in another part of this report. The subject of peat and peat marshes is also more especially discussed in a chapter devoted to that subject.

Geology. Both these counties, except perhaps the southwestern part of Cerro-Gordo, are thought to be wholly underlaid by strata of Devonian age immediately beneath the drift. They are freely exposed in the valleys and are also not unfrequently found at the surface at considerable distances from the streams in their eastern portions. The exposures are almost continuous in those portions of the valleys of Lime creek and the Shellrock that lie within Cerro-Gordo county. The following section will give an idea of the general lithological characters of the strata of the region. It was measured in the left bank of Lime creek, about a mile above Mason City:

Section near Mason City.

No. 4.	Irregularly bedded, concretionary limestone	4	feet.
No. 3.	Grayish or dove-colored limestone.....	15	feet.
No. 2.	Coarsely granular limestone, probably magnesian.....	2½	feet.
No. 1.	Uniformly bedded, magnesian limestone	8	feet.
Total.....		29½	feet.

The concretions of No. 4 are really masses of *Stromatopora*, a fossil usually regarded as of coralline origin. It prevails largely in all the Devonian strata of Iowa. The prevailing character of the stone of the strata of this age in this part of Iowa is light dove-colored, compact, common limestone, which is inclined to become fragmentary upon exposure. The magnesian member, No. 1, is not so frequently exposed, but it is quite important, reaching a thickness in some places

of about fifteen feet. The most westerly point at which strata of Devonian age are exposed in Cerro Gordo county, and probably the most westerly one in Iowa, is a couple of miles east of Clear lake, on the Mason City road. It forms a knob-like outlier, fifteen or twenty feet in elevation above the prairie surface around it, and is composed of yellowish, earthy, and clayey, friable limestone, which readily decomposes to the condition of soil upon exposure to the atmosphere and frost. These are probably the highest beds of Devonian age in the State. Their Devonian age is clearly proven by the characteristic fossils found there.

Material Resources. These counties, but more especially Cerro Gordo, are plentifully supplied with stone, much of which is of excellent quality for building purposes. Much the greater part of it at every exposure is excellent material for the manufacture of lime, and all of it is suitable for common purposes. The magnesian strata being more uniformly bedded, and of dense and uniform texture, may be made to furnish excellent material for dressed stone and for bridge piers or other heavy masonry. Some of the common limestone near Mason City is thinly and uniformly bedded, and having a light gray color, looks well in walls of business houses, which have been constructed of it at that place, and even in residences also. The equivalents of these beds appear most frequently in Worth county where the magnesian layers have not been observed. In the latter county, indeed, the only exposures observed are in the valley of the Shellrock.

In the banks of the lakes and larger streams a fair quality of sand may be obtained for building purposes. Clay also, suitable for bricks, may be obtained in sufficient quantity to meet all requirements; but it is nowhere so abundant as it is in the southern part of the State. Near Plymouth, Hon. C. W. Tenney pointed out some places in the banks of a creek, where a grayish clay was visible, but so far as could be ascertained the deposit is not large. Similar clay has been observed elsewhere in this and other counties in which the

Devonian strata are exposed. It probably originates from clayey beds that alternate with the limestone, and may, in some places furnish valuable clay. It is, of course, not to be expected that coal, in anything like profitable quantity will ever be found in either Worth or Cerro Gordo counties. Indeed, the only traces that may be looked for are the loose lumps in the drift that have before been mentioned. The inhabitants must therefore draw their supplies of fuel from the peat marshes and the present and prospective growth of forest trees. Both these counties are as well supplied with fuel in the form of wood as any of the counties of Northern Iowa; but besides this they each possess several thousand acres of good peat marsh, so that there need be no fears of future scarcity of fuel.

The streams and lakes of this region afford constant supplies of pure water. Springs are also numerous and wells may be obtained upon the prairies at only a few feet below the surface.

Like the greater part of Iowa, it is the fertile soil of these counties that constitutes the source of wealth for the future inhabitants as well as the sure support of those who now occupy it.

CHAPTER IV.

GEOLOGY OF THE COAL COUNTIES.

1. GENERAL REMARKS.

The original plan of this report provided for a chapter under the above heading that should include complete details and illustrations of the geology of each county of the State within which it is known that coal exists. The preparation of a report upon such a plan has been prevented by the failure of the legislature to make any provision for continuing the Geological Survey, and also by their order to have the report printed as it was presented to them; this chapter being omitted. Desiring, however, to make the report as complete as possible, the following has been prepared as a substitute for the chapter originally intended, the publishers generously including it, although not provided for in their contract. It has been compiled from more or less incomplete notes made by different members of the geological corps during the progress of the survey, and from private notes by the writer, made before and since that work was in progress. This explanation is made to show that the incomplete and imperfect character of this chapter, which ought to be one of the most complete in the report, has been unavoidable.

2. WEBSTER COUNTY.

The usual deep deposit of drift covers the surface of Webster county, hiding from view the underlying strata except in the valleys. Although the strata are thus hidden from view elsewhere, it is believed that about four-fifths of

the area of the county are occupied by the Lower coal-measures, the strata of which, including valuable beds of coal, are well developed. These strata are more fully developed, and their coal-beds thicker and better than might be expected in view of the fact that the northern border of the Iowa coal-field is understood to pass through the northern part of this county.

The accompanying lithograph section of the Carboniferous strata of Webster county, shows the coal-measure strata resting upon the St. Louis limestone formation of the Sub-carboniferous group, and a diagram accompanying the chapter on the gypsum deposit of the same region shows the order of superposition of the three formations.

Thus far, at least three distinct beds of coal have been identified within the limits of Webster county, the upper one of which seems to be the thickest, purest, and consequently the most valuable. It is only along the valley-sides of the Des Moines and its tributary creeks that these beds are at present accessible, but there can be no doubt that they may be reached by shafts from the prairie surfaces, over a large part of the county. One of these beds, perhaps the lowest, has for some time been successfully mined at Fort Dodge by Judge Rees and others, but the best and most abundant supplies have thus far been obtained from the valley-sides of Holloday's creek, four or five miles below the city. The principal bed worked there, measured about five feet in thickness at the time we visited it, but by further working, it is since reported to present a thickness of over six feet. Openings showing this increased thickness have been made on both sides of the river valley, and being at considerable distance from each other, it seems quite certain that the thickening is not a mere local "pocket," but that it occupies a very considerable area. This promises to prove the vicinity of Fort Dodge to be one of the most important portions of our coal-field, notwithstanding its close proximity to the border. If the other two beds should not prove to be of sufficient thickness to be profitably worked, which there is no reason

at present to assume, this thickest bed alone will furnish immense quantities of coal both for local use and for shipment, for there are good reasons for believing that the same bed may be as successfully mined in various other parts of the county.

Since the Sub-carboniferous limestone appears in the bed and banks of the Des Moines for a distance of several miles, and it being well known that the general depth of all the strata is very slight, the uselessness of searching for coal much, if any, below the level of the bed of the river in this county, will be readily seen. In all cases when that limestone is reached, digging should be at once discontinued. The quality of the coal of Webster county is equal to the average of Iowa coal.

Although a large part of the county is prairie, wood-fuel is also quite abundant along the valleys.

The Sub-carboniferous limestone, abundantly exposed in the valley of the Des Moines, at and above Fort Dodge, affords plentiful supplies of good material for building purposes and for lime. Besides this, the gypsum, as shown in another part of this report, is also used extensively by the inhabitants for the same purposes that common stone is usually applied to elsewhere.

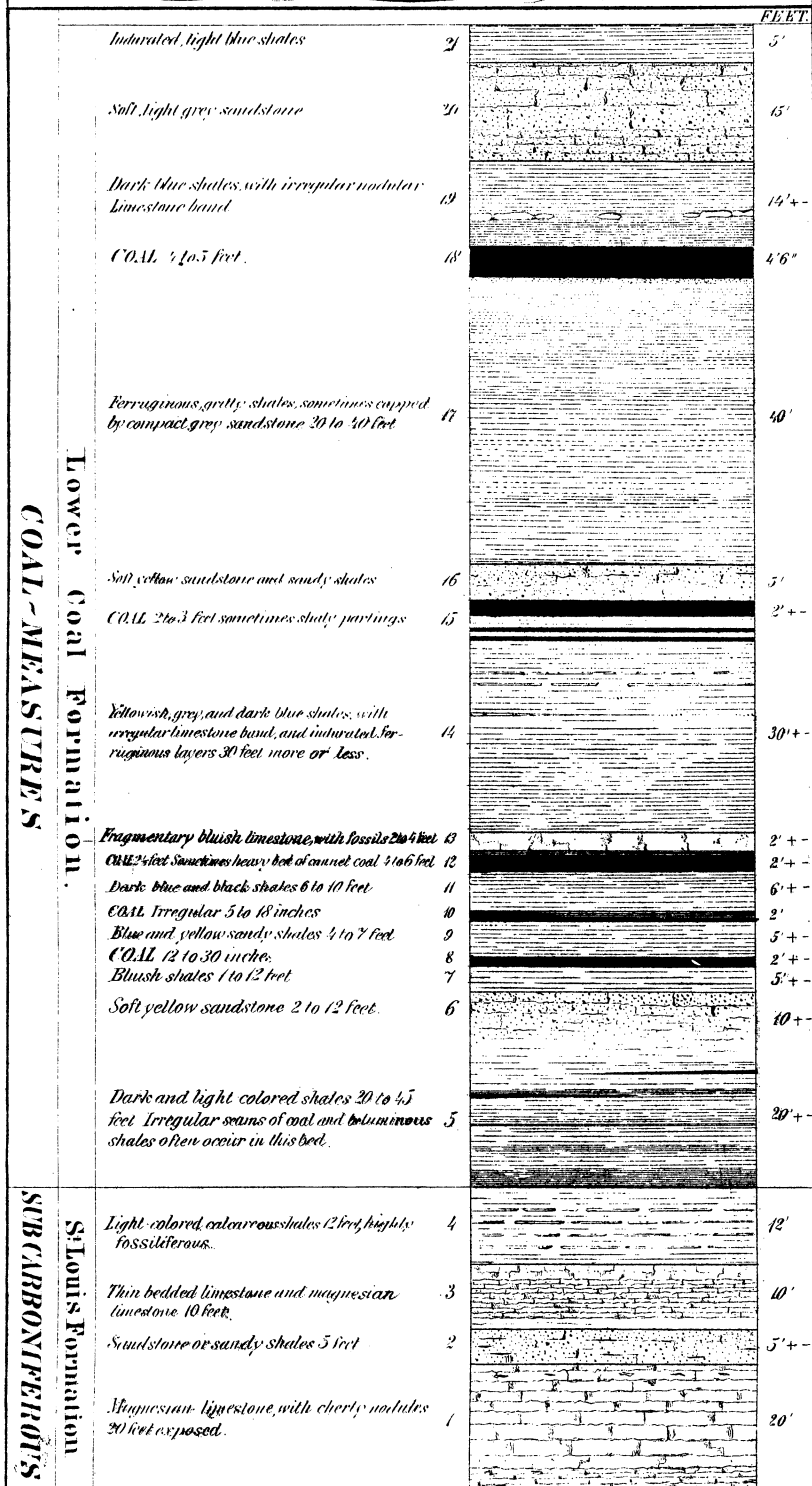
3. HAMILTON COUNTY.

Geologically, Hamilton closely resembles Webster county. Like that county, it is covered deeply with drift, the stratified rocks appearing only in the valley of the Boone. This being a smaller stream than the Des Moines there are fewer natural exposures of strata in its valley, but those of the Lower coal-measures and also of the Sub-carboniferous limestone are found there. The latter appear in the bed and banks of the river at Webster City, and also some six miles below, at Sternberg's mill, where the coal-measure strata are seen to rest upon the limestone.

Although the exposures of coal-measure strata are comparatively few and only found in the valley of the Boone,

GENERAL SECTION

Carboniferous Strata in the vicinity of Fort Dodge



there are good reasons for believing that the greater part of the county is occupied by them immediately beneath the drift; the northern border of the Iowa coal-field being understood to cross its northern part as it does that of Webster county.

Thus, while it is not likely that coal-beds of profitable thickness will be found in its northern tier of townships, it is quite reasonable to assume its existence in the greater part of the remainder of the county. The Sub-carboniferous limestone, as before said, appearing in the bed and banks of the Boone, and the formations having only a very slight general dip, it is evident that no coal need be sought for much, if any, beneath the level of the bed of Boone river. Between that level and the base of the drift, much coal, doubtless, exists, especially in the southern part of the county. During the brief examination given to this region the existence of only one valuable bed of coal was satisfactorily made out. The natural exposures of this bed are in the valley-sides, above the level of the bed of the stream, and may there be most conveniently mined; but the same, no doubt, may be also reached by sinking shafts down to about the same level from the prairie surfaces in other parts of the county. This bed is about four feet in thickness, and was found naturally exposed at several points between Webster City and the confluence of the Boone with the Des Moines river. The quality of this coal is about the same as that of Webster county.

Aside from this coal the woodland of the valley of the Boone and those of its tributary creeks furnish large supplies of wood for fuel.

4. HARDIN COUNTY.

By reference to the map accompanying this report, it will be seen that the border of the Iowa coal-field is represented as making an abrupt bend to the southward in Hardin county. The coal-measure strata are found exposed in the valley of the Iowa river at intervals, from the point where it enters, to

where it leaves the county; but it is in the immediate vicinity of Eldora that the fullest development of them has been observed, and where only a workable bed of coal has been found within the county limits. These strata are seen at several points to rest directly upon those of Sub-carboniferous age, but the latter belong to a different formation of the Sub-carboniferous group from those which immediately underlie the coal-measures in Hamilton and Webster counties, as has been shown in another chapter of this report.

The position of the exposures of these coal strata, so much to the northeastward of a line indicating the general trend of the border of the coal-field, suggests that the Eldora coal region may possibly be a large outlier from the main field, similar to, but not so far removed, as the coal-measure outlier lying between Muscatine and Davenport. The Eldora mines are, however, of great importance and value. Different parties have mined coal there for several years past, to supply local demand, but within the last three years the Eldora Coal Company has opened and worked mines upon a more extensive scale, shipping much coal upon the Central Railroad of Iowa and the Dubuque and Sioux City Railroad. At the various points where this bed has been mined, it measures about four feet thick. It is underlaid by clay and clayey shales to considerable depth. These have been penetrated by a drill with the hope of finding another bed of coal beneath the one now worked, but without success.

Aside from the intrinsic value of these mines, the importance of the region is much enhanced by being the most northeasterly one within which coal has been or is likely to be obtained. The county has also an additional supply of fuel in the woodland of the valley of the Iowa river, the growth of forest trees upon which is rapidly increasing.

Some excellent potteries are established at Eldora, using the clay from the bed which underlies the coal there. In the northern part of the county, especially at Iowa Falls, there are abundant supplies of limestone, suitable for common and dressed building stone and for lime.

5. BOONE COUNTY.

The whole of Boone county lies quite within the recognized limits of the coal-field, and yet, so far as known, coal has been actually discovered at only a few points near its center. This is, doubtless, in great part due to the great depth of the drift which covers the strata of the whole county, and also in part, perhaps, to a supposed general depression of all the strata, so that the Sub-carboniferous as well as the lower strata of the Lower coal-measures are brought somewhat beneath the level of the bed of the Des Moines river along the whole length of the county.

Coal has been extensively worked near Boonsboro and Moingona, upon the line of the Chicago and Northwestern Railway, by two companies organized for that purpose. Besides this, considerable quantities have been mined by private parties to supply local demand. All these mines have been opened in the valley-sides of the Des Moines river and Honey creek, one of its small tributaries.

There are two distinct beds of coal known and mined here, the principal one being the lowest and about four feet thick. The upper one is from two and a half to three feet thick. The quality of the coal is equally as good as that of the other, but requiring, proportionally, more labor, it is not so extensively mined. These being the only mines yet opened on the line of that railway in Iowa, they are of great value and importance. There can be no reasonable doubt that these or other beds of coal may yet be reached by sinking shafts from the prairie surfaces of different parts of the county at a comparatively moderate depth.

Potteries of considerable importance have been successfully established at Boonsboro, using the clay found there associated with the coal strata.

6. STORY COUNTY.

Although Story county lies quite within the limits of the coal-field, as indicated upon the geological map accompanying this report, no workable bed of coal, so far as yet

known, has been discovered within its borders. The few exposures of strata yet found, were observed in the valley of Skunk river, near Ames, some three miles northwestward from the village. Here, in the bed and banks of the stream, we found exposures of impure and shaly limestone, overlaid by softer and clayey strata. The latter seem to belong to the coal-measures, but the former are, undoubtedly, of Sub-carboniferous age, and of the epoch of the St. Louis limestone. This, of course, indicates that the *base* of the coal-measure formation is not far from the surface anywhere in that vicinity, and this fact strongly suggest a slight development of it over the whole county. However, there is no reason to doubt that coal of workable thickness may yet be found within its limits, but it must be confessed that the chances of finding it may be regarded as more hazardous than they might have been considered before this discovery.

7. MARSHALL COUNTY.

So small a proportion of Marshall county is occupied by the coal-measures that it can hardly be enumerated among the more important of the coal counties. Some valuable deposits of coal, however, have been found in its northwestern corner, and it is not improbably that other discoveries of it may yet be made in the western and southwestern portions. No valuable deposits of coal need be sought for in the central and eastern portions, from the fact that the Sub-carboniferous strata occupy those parts, lying immediately beneath the drift. Beneath this limestone it is, of course, useless to look for coal. The top of the same formation cannot be far beneath the surface in the western part of the county ; consequently, all the coal found there will be at comparatively slight depth.

Considerable bodies of woodland along the valleys of the Iowa and its tributary creeks, furnish all necessary fuel besides the coal.

The quarries of Marshall county are referred to in another part of this report.

8. POLK COUNTY.

Polk county is nearly centrally located among the coal counties of Iowa, and although large quantities of coal may be reasonably assumed to exist beneath its surface at no great depth, it has not yet been extensively mined except at, and in the immediate vicinity of Des Moines.

The mines of Messrs. Redhead & Co. are opened in the valley-side of the Des Moines river, just north of and adjoining the city; and those of C. C. Van & Co., just south of the city, in the valley-side of the Raccoon. Other mines are also worked in East Des Moines, just south of the Capitol; and still others may be opened at numerous points around the city, for the same bed of coal has about the same general level throughout the vicinity, having been originally continuous and afterwards cut through by the carving out of the valleys of the Des Moines and the Raccoon. No data have been obtained showing the amount of coal annually taken from these mines; but, in general terms, it may be said that they supply the whole city and vicinity; the railroad companies for their own use, and also a considerable quantity for shipment.

As before mentioned, these mines are all in one continuous bed, or more properly speaking, in three separate beds, which has here come so closely together that they are readily mined as, and appear like one bed, either one of which would be too thin for profitable working if alone. This compound bed has been recognized as far west of Des Moines as Redfield, in Dallas county, and as far southward as Indianola, in Warren county, as has been more fully shown by Prof. St. John.

There is a fourth thin bed of coal a few feet beneath the others, as seen at Des Moines, which, at Newcomer's Point, five or six miles below the city, is some twelve feet beneath the representatives of those worked at the city. At Rattlesnake bend, some eight miles below the city, a three-foot bed of coal is exposed in the channel of the river, where, at low water, it is sometimes quarried for local use.

The sub-carboniferous limestone does not appear in Polk county, even in the bed or banks of the Des Moines, and it is evidently at some depth beneath that level throughout the county. It seems, therefore, not improbable that other beds of coal, besides those referred to, may yet be found beneath them at Des Moines, as well as elsewhere in the county. Some borings have already been made at Des Moines, but efforts to obtain any satisfactory account of the strata passed through have failed.

Besides the coal contained within the county it is also quite well supplied with fuel from the woodlands which occupy the valleys of the two rivers.

The clay associated with the coal-beds of Des Moines, furnishes excellent material for common pottery, and two establishments are in successful operation in the city for its manufacture.

9. JASPER COUNTY.

Jasper has long been practically known as one of the coal-counties of the State, the coal hitherto having been mined near its central portion at several points a few miles southward, and westward from Newton, the county seat. No especial geological examination having been made in this county, little is known except the general facts that the coal is quite extensively mined, of good average quality, and that the bed is about four feet thick. The county lies quite within the recognized limits of the coal-field and large supplies of coal may be reasonably relied upon for the future.

10. WARREN COUNTY.

Although Warren county is described and especially referred to in other parts of this report, the general remark may be made here, that although its thickest and best beds of coal are now found in the northeastern portion, there is good reason to believe that equally good beds may be reached by sinking shafts of moderate depth in almost all parts of the

county, passing through the thinner beds now known near the surface there. It is probable that Warren county will some day rank among the best coal counties of the State.

11. MARION COUNTY.

Marion is without doubt one of the best coal counties of the State. Indeed, except in the immediate valley of the Des Moines, and in the lower portions of some of those of its tributary creeks, a shaft of two hundred or three hundred feet depth at most, could hardly fail to pass through one or more coal-beds.

At least three different beds of coal exist in the county, but the necessary details concerning them have not been worked out, so that it is not certainly known whether the principal bed of each particular locality where it is observed, constitutes one continuous bed, and the other beds always unimportant; or, what is more likely the case, whether each is in turn the principal bed in some localities, the other two being absent or unimportant.

The following are notices of some of the principal mines and natural exposures of coal within the county. Near Otley station, on the Des Moines Valley Railroad, about seven miles westward from Pella, Mr. Roberts, Mr. Fisher, and Mr. Barnes have each opened mines in the valley of a tributary creek of the Des Moines, where the coal, evidently the same bed, varies from four feet to six feet in thickness within half a mile. Four miles southward from Pella, Mr. Nossaman has opened and worked a three-foot bed of coal. This is without doubt the lowest bed of coal in the series, since the Sub-carboniferous limestone is exposed at the same point twenty-five feet beneath the coal-bed.

At Coalport, a little village some four or five miles from Pella, there is a natural exposure of two beds of coal. They appear, the one above the other in the face of a bluff immediately upon the right bank of the Des Moines river. They are only some ten feet apart, the lower

being about two feet thick, and hardly workable, while the other is between six and seven feet thick, the coal being excellent. Mr. H. F. Bousquet has opened a mine in the latter bed.

About two miles north of Knoxville, Mr. O'Neal has opened a mine in the valley-side of Whitebreast creek. Here two beds of coal have come so nearly together as to be conveniently mined as one. Just upon the southern border of Knoxville, Mr. Brobst has opened a mine in a four-foot bed of coal, which also, no doubt, underlies the whole town. Along the valley of English creek, from a point immediately south of Knoxville, to where it merges with that of the Des Moines, coal is frequently exposed in the valley-sides. The thickness of the coal along this creek varies from three to seven feet, evidently thickening to the eastward, so that near Bussing's mill, it reaches the last named thickness. Near this mill, which is about four miles east of Knoxville, another bed of coal appears about fifteen feet beneath the principal one, but which is only about one a half feet thick.

Coal, from five to seven feet thick, is found at frequent intervals in the valley-sides of North and South Cedar creeks, ranging from the points where they enter the county to where they unite and enter the valley of the Des Moines. Just where South Cedar creek crosses the southern boundary of the county, the coal is exposed by the creek showing a thickness of between six and seven feet. A mile above Marysville, Mr. Jacob Kline has opened a mine in which the coal has a thickness of nearly ten feet, but looking closely, it is seen to consist of two separate beds, with only a thin parting of shale between them. The lower one is nearly seven feet thick, and the upper near three feet, the lower being evidently the best coal. At Marysville, John Yenser, D. F. Leiby, and the Mill Company have all opened mines in the same bed, which there measures from five to six feet thick. A couple of miles below the village, G. F. Clemons has opened the same bed, where it has about the same thickness. Daniel Sherwood has opened a four-foot bed

a couple of miles southeastward from Attica. A natural exposure of coal appears in the bluff bank of North Cedar, on section 16, township 74, range 18. A. B. Lyman, Esq., has also made some openings of coal farther down the creek.

These are only references to the principal mines and natural exposures of coal in Marion county. Many others are already known, and there is hardly a limit to the number of mines that may be conveniently opened within its limits. Besides its coal, it is also one of the best timbered counties in the State.

It is also well supplied with stone compared with most other counties of the State. The Sub-carboniferous limestone is exposed at intervals near and within the valley of the Des Moines river, from a point a few miles above Pella to the southern boundary of the county. Just north of Pella, Philip Mathes has quarried much of this rock for both common and dressed work, principally the latter. The material is of good quality for caps, sills, lintels, dressed walls, etc., and is much used for such purposes. Wherever the limestone is found it may be made to produce excellent lime, and much is already burned in various places.

At Redrock, the coal-measure sandstone has a full bluff exposure upon the left bank of the Des Moines. It is here mostly of a light brick-red color, and much of it is hard and firm enough for use in good buildings. It may be quarried in almost any desired shape, size, or quantity.

12. MAHASKA COUNTY.

None of the coal counties of Iowa, so far as is now known, exceed Mahaska county in importance as regards its supplies of coal, unless it be Marion county. So far, however, as the quantity of coal now annually mined is concerned, Mahaska county is much in advance of any of the others. Although the greater part of the mines of this county have been examined, the formation which contains them has not been studied as a whole, within its limits, with sufficient thoroughness to give a clear statement of the number of different

beds of coal it may contain, and their relations with the other strata.

In the north part of the county, near the confluence of Buck creek with the north branch of Skunk river, several mines have been opened in a four-foot bed of coal to supply the limited demand there.

Spring creek rises just east of Oskaloosa, and, running northward about three miles, it empties into South Skunk river. Along the valley-sides of this creek, several openings have been made, the coal presenting a thickness of from four to five and a half feet. It is not clear that all these openings have been made into one and the same bed, for there are indications that two beds of coal, one not many feet above the other, exist there and both workable. Much coal may be readily obtained there, even if there is but one bed.

Around the outskirts of Oskaloosa, several mines have been opened, in which the coal varies from three and a half to five and a half feet in thickness, all of which mines are probably in the same bed, and which, no doubt, underlies the whole town.

At Oskaloosa station, two and a half miles from the town, the most important coal mines yet opened in the State, are located. At the time these mines were visited, the coal presented a thickness of from five to nearly eight feet of solid and good coal. It is reported to show a still greater thickness upon further working. These mines are opened in the valley-side of Muchekinock creek, and the thickness of the coal being so great, mules of ordinary size are employed to draw the loaded cars from the workmen in the mines to the station platform of the Des Moines Valley Railroad, without unloading, or any other change. The two principal mines here are operated by Messrs. Roberts & Co. and the Iowa Coal Company of Keokuk.

At Given station, four miles below, these mines are worked by the company just mentioned, in the opposite side of the same creek-valley, the bed being there about four feet thick.

Other mines have also been slightly opened at several

points in the same valley, and in those also of its tributary branches. At one of those places, a few miles below Oskaloosa station, there are indications of the existence of two workable beds of coal.

Since the Sub-carboniferous limestone appears in the beds and banks of Des Moines and Skunk rivers, and Muchekinoch creek, it is evident that no coal need be sought for below that level; but the amount which exists within the county, between that limestone below, and the drift above, is immense, although the coal formation probably nowhere exceeds one hundred and fifty feet in thickness within its limits.

13. KEOKUK COUNTY.

Although Keokuk county lies quite within the limits of the coal-field, as defined upon the geological map, it is not probable that it will ever take rank among the more important coal counties of Iowa. This statement should not be understood to imply that no important deposits of coal exist within its limits, because it is a well known fact that some good mines are already opened there. The county, however, lies near the eastern border of the field, where the coal formation would naturally be expected to be thinner, besides which, the Sub-carboniferous limestone is so exposed along the valley of Skunk river, as to show that there cannot be in many places any considerable development of coal-measure strata between that limestone and the drift above. Of course no coal need be sought for beneath that limestone. No detailed examination of this county has been made, and the forementioned general facts only have been ascertained.

14. MONROE COUNTY.

Monroe county, lying well within the coal-field, has, as would naturally be expected, a fuller development of the coal-measure strata than those counties have which lie upon or near the borders of the field. In some portions of this county the Middle coal-measures are found resting upon the

Lower, which they have never been found to do in any of the coal counties east of the Des Moines river. It is shown in another part of this report that the coal-beds of the Middle measures are thinner, as a rule, than those of the Lower. Therefore, the coal-beds found in the central portions of the county are thinner than those found in the creek-valleys of the eastern and northern portions. These last named beds belong near the base of the Lower coal-measures, and it is reasonable to infer that they underlie the whole county beneath the others.

In the valleys of Miller's creek in the northeastern part, and of Bluff creek in the northern part of the county, some openings have been made in a four-foot bed of coal. In the valley of Cedar creek, in the northwestern part, the same thick bed of coal is found that is so frequently exposed in the southeastern part of Marion county. In the valley of Avery creek, near the east boundary of the county, several openings have been made in one of the lower beds, the coal measuring about four feet thick, and at one point reported to reach five thick in thickness. Besides all these, several openings in the upper and thinner beds have been made in various parts of the county; the coal of these often being of superior quality, it is found profitable to work them although they are so thin as compared with the others.

Thus, the region embracing the northern part of Monroe, the principal part of Marion, the southern part of Mahaska, and the northwestern corner of Wapello counties constitutes what is now regarded as the finest part of the Iowa coal-field.

15. WAPELLO COUNTY.

As regards the amount of coal now annually mined, it is thought that Wapello county ranks second to none except Mahaska, and yet only a beginning is made in either, compared with what may, in the future, be done.

Only a few of these mines can be mentioned in this place. Just west of Chillicothe, Messrs. Dudley & Co. have opened a

mine in a four-foot bed of coal, in the valley-side of South Avery creek. About forty-five feet beneath this coal-bed, as may be seen in the bank of the creek near by, another bed of coal exists; but the quality is poor and the thickness only about one and a half feet. On the opposite side of the valley, about a mile distant, Mr. Heacock has opened a mine, evidently in that lower bed, and not the one in which Dudley & Co.'s mine is opened. This lowest bed is very near to the Sub-carboniferous limestone, and the quality usually inferior. The second bed, however, is usually very valuable, both as regards quality and thickness.

Three miles below Chillicothe, Henry Shock & Co. have opened a mine in the valley-side of the Des Moines river, the coal measuring about five feet in thickness. They furnish large quantities of coal for shipment on the Burlington and Missouri River Railroad.

About a quarter of a mile from the last named mine, Mr. David C. Evans has opened another in the same bed, the thickness being about the same.

In the immediate vicinity of Ottumwa several mines have been opened in apparently two separate beds, but they are rather thin, and the quality poorer than that of the coal of the county will average. The city evidently cannot depend on the coal mined within its limits, but it must be brought from mines four or five miles distant.

About that distance to the northwestward, Messrs Brown & Godfrey have mines in a four foot bed, from which they are prepared to ship coal on the Des Moines Valley, and Burlington and Missouri River railroads, both of which pass near their mines.

About a mile south from Kirkville, some eight miles northwestward from Ottumwa, several other mines have been opened in a bed that measures from four to five feet in thickness of good coal.

In the immediate vicinity of Eddyville, several mines have been opened in a bed measuring from three and a half to four feet thick, the quality of the coal being excellent.

At Alpine Station, on the Des Moines Valley Railroad, in the southeastern part of the county, the Alpine Coal Company, under the direction of Mr. C. J. Love, has opened extensive mines, from which they ship large quantities of coal upon the railroad.

In the southwestern part of the county some thin exposures of coal are found, similar to some of those in Monroe county. Like those, they probably belong to the Middle coal-measures.

16. APPANOOSE COUNTY.

Although coal has not been worked to so great an extent in Appanoose, as in some other counties, yet no difficulty is experienced in obtaining all that has hitherto been needed, and there are good reasons for believing that coal exists beneath its surface in large quantities.

It is now known that all three of the divisions of the coal-measure group occupy the surface beneath the drift; the Lower occupying the northeastern portion, the Middle traversing it near the centre, and the base of the Upper appearing as limestone ledges a little west of Centreville. In the valley of Cooper's creek, two miles west of Centreville, Mr. Talbot has opened a mine in a three-foot bed of coal of good quality. This is regarded as the upper bed of the Middle coal-measures, and whatever other beds may exist within the county, doubtless, belong beneath it. Thus, the place of all the heavy beds of coal found elsewhere, is at considerable depth here, but they may be looked for nearer the surface in the northeastern part of the county. It is believed that a shaft sunk in the valley of Chariton river, near Centreville, would pass through all there is there of the coal-bearing strata within three or four hundred feet. There are good reasons, also, for believing that one or more good beds of coal would be passed through at that or a less depth, besides the one now worked by Mr. Talbot. See also Prof. St. John's remarks upon this county on other pages.

17. DAVIS COUNTY.

Davis county is known to contain large quantities of excellent coal, but since the streams which traverse it, are none of them large, they have not exposed much of it by the erosion of their valleys. All the mines or exposures visited in this county, are in the valleys of Soap and Salt creeks, in the northern part, where the coal-measures are about four feet in thickness. Davis is bounded on every side by well known coal counties, and no reason is known why it should not ultimately rank among the best coal counties in the State.

18. VAN BUREN COUNTY.

Van Buren is among the counties within which coal was first discovered in Iowa; consequently, some of the oldest coal-mines in the State are located here. The results of a very full examination of this county, by Prof. A. H. Worthen, are given in the former report upon the Geology of Iowa, and the only object of these paragraphs is to notice briefly its deposits of coal.

The full thickness of the coal-bearing strata in Van Buren county is not accurately known. It probably nowhere exceeds one hundred and fifty feet, and is known to be usually much less. The number of different beds of coal has not been fully made out, but there are probably three, only one of which is usually of sufficient thickness for profitable working. This bed, if it be always the same one in which the mines are opened, is of very considerable importance, and from it large quantities of coal have been, and very much more may yet be obtained. Mr. McHugh has long had a mine opened in a three and a half-foot bed of coal a little below the town of Independent, in the extreme northeast corner of the county. About two and a half miles eastward from the same town Mr. Rodefer has a mine opened in a four-foot bed. About half a mile up the same creek valley in which the latter is located, another opening has been made in a four-foot bed, which appears to be a separate bed from the other, lying

quite above it. Half a mile south of Business Corners, Mr. Alexander Findlay is working one of the oldest mines in the county, in a three and a half foot bed. A little south of this, near Doud Station, Hon. Eliab Doud, formerly had some mines in successful operation, and they may, no doubt, be profitably re-opened. At, and in the vicinity of Keosauqua, several openings have been made in a bed of coal about three feet thick, which have for many years, been worked to supply local demand. A couple of miles northward from Bentonsport, Mr. Carter has opened a three foot bed of coal, and several others have also been made in the same township.

At Farmington, large quantities of coal were formerly mined, and shipped upon the Des Moines Valley Railroad, by a company organized for that purpose. These mines were successfully and profitably worked until those extraordinarily rich mines of Oskaloosa Station, on the same railroad, were brought into competition with them. The Farmington mines first mentioned are located upon the east side of the Des Moines valley. Messrs. Dibble, Wright, and Tuttle also had mines in operation upon the west side.

In the northeastern corner of the county, some mines have been profitably worked for many years to supply a local demand from a thickly settled farming region.

There have been also many other openings made into the coal-beds of this county, all of which show that very large quantities of coal exist there, and the only question is one of competition with the extraordinary, mines of counties near by.

The clay associated with the coal-bearing strata of this county has been extensively used at Vernon by Mr. Dickson for the manufacture of common stone pottery. The quality of it appears to be equal to that of any other in the State for that purpose.

Some citizens of Farmington have bored an artesian well at that place, to a depth of seven hundred and five feet. A full flow of water was obtained, rising to the top with

considerable force. After three years, it is now discharging freely and constantly. Prof. Emery gives an analysis of the water in another part of this report.

19. JEFFERSON COUNTY.

Jefferson county has also long been known as a coal county. At Coalport, ten miles eastward from Fairfield, near the Burlington and Missouri River Railroad, Messrs. Brown and Co. are working a mine in a four-foot bed of coal. Directly upon the line of the same railroad, a little west of Fairfield, other mines have been long worked by Mr. Heron and Mr. Richardson. Much coal is shipped upon the railroad from all three of these mines.

Some six or eight miles north of Fairfield, in the valley of Walnut creek, there have been a number of mines opened in a four-foot bed of coal. Being at some distance from the railroad, there is less demand for the coal than there otherwise would be, so that Mr. Shaw's mine is the only one we found in operation.

In the valley of Cedar creek, a few miles southward and westward from Fairfield, a bed of coal has been frequently opened which measures from three and a half to four feet in thickness. The mine in most successful operation at the time of our visit was that of Messrs. Young & Stubbs. At their mine, another bed of coal, nearly two feet thick, is seen in the valley-side, with about twenty feet of intervening sandstones and shales. At Read's mill, three miles southwestward from Fairfield, a good mine is in operation, the coal of which is taken out of the pit by the machinery of the mill.

Washington county is known to contain some coal in its southwestern corner, and it is not improbable that some may also exist in its western and northwestern portions in the form of outliers, but it is hardly probable that, after railroad transportation becomes more general, coal can be profitably mined within its limits.

Several of the counties west of the Des Moines river, not

mentioned here, are well known to contain coal; but they are quite fully reported upon by Prof. St. John, on other pages.

Besides this, *Muscatine* and *Scott* counties contain much coal, which is found in a remarkably large outlier, resting upon Devonian strata and extending from Muscatine nearly to Davenport. The coal of this outlier consist, so far as at present known, of a single bed seldom exceeding three feet in thickness, and although of great local value, it can hardly compete with others conveniently situated upon or near railroads.

PART II.

MINERALOGY, LITHOLOGY, AND CHEMISTRY.

CHAPTER I.

PEAT, PETROLEUM, &c.

1. PEAT.

This substance, under various names,* has been in use for centuries in various parts of the world, chiefly for fuel. In some countries it is the principal kind of fuel in use, the inhabitants using it not with dislike and compulsion, but with actual favor. It has long been in limited use in some parts of the eastern portion of our country; but the first public notice of its existence in Iowa, so far as known, was given by Dr. C. C. Parry, the well known botanist, in a communication to the *Davenport Gazette*, in February, 1866. In the summer and autumn of 1867, I devoted some months to the examination of the peat deposits of Iowa, mainly in the middle region of the northern part of the State.

Peat is not, properly speaking, a mineral fuel, although sometimes classed as such. It is always formed upon the surface, and except in very rare instances, it has no other covering than the vegetation growing upon it. It has its origin in the partial decomposition of the vegetation that

* German, Dutch, and Swedish, *Torf*. French, *Tourbe*. English synonym, *Turf*.

grows upon the spot where the peat accumulates; the conditions of its formation being the constant moisture of the fallen vegetation and a comparatively low temperature. It is not sufficient that moisture is applied to the accumulated vegetable debris during the greater part of the year and absent during the heats of the summer, for the plants which enter into the composition of peat not only need constant moisture for their continuous growth, but its presence is also necessary for the proper carbonization of the dead vegetation. If, in the warm season, the latter becomes dry, entire decomposition takes place, as it does with the last year's grass of the prairies when they escape the fires, and no peat is formed.

After peat has begun to form, both that and the water which permeates it possess antiseptic properties, and thus complete decomposition of the added vegetation has a still farther check. In some portions of the earth, the great moisture of the atmosphere is sufficient to supply the necessary moisture for the formation of large deposits of peat, but with rare exceptions this moisture is supplied from the earth. Sometimes the deposit of peat is found upon a hill, or mountain side, or other elevated ground, where springs issue upon and flow over the surface upon which it accumulates. Or it fills shallow ponds, the water of which becomes displaced by the gradual accumulation of peat around the margin. Again, it largely prevails where in low marshy districts the necessary constant supply of moisture is derived from adjacent seas, lakes, or rivers.

Much the greater part of Iowa peat has been formed in ponds, upon the borders of which rank grasses and other plants have grown profusely until the frosts of each returning autumn laid them beneath the surface, the accumulation of their comminuted fragments narrowing the area and lessening the depth of the water, until the place becomes the proper habitat of peculiar mosses which continue to grow above the rapidly decomposing bodies of the parent stems, without the necessity of a proper root. The substance produced

by this decomposition, together with similar remains of grasses and other plants which grow with the moss, has in time accumulated until the pond has become a peat marsh upon which a man may walk dry shod during almost any part of the year. Some of these ponds are now in process of being filled, a broad margin of peat marsh surrounding a central space of open water, while others are filled with peat to the brim, the surface being as level as the surface of the water was that formerly filled the pond, and yet firm enough for a man to walk upon it with safety.

This description applies particularly to the peat marshes of the Middle Region of Northern Iowa, which is the principal peat region of the State. This peat region extends northward to the northern boundary of the State and beyond; but southward, as a distinctive region, only to about latitude $42^{\circ} 30'$. The peat region is not definitely bounded on the east by Cedar river, nor on the west by the west fork of the Des Moines, but the space between these two rivers comprises its principal portion. In this region nearly all the marshes yet observed rest in depressions of the undulating surface of the Drift Deposit. The valleys of the streams of that region do not have those well defined limits to the flood plain and upland which are so characteristic of the majority of the valleys of Iowa, but there is usually a gentle and almost imperceptible descent from the uplands to the stream, so that one can hardly say where the former begins and the flood-plain ends. The whole surface of the country, from near the streams to the low dividing ridges between them, is undulatory, so that the appearance of the slope is obscured. Thus, the marshy depressions are as numerous and the peat as abundant in the vicinity of the watershed as nearer the streams upon lower ground.

The common prairie grasses and plants cover the general surface of the country, for it is mostly prairie; but usually, as soon as the border of the marsh is reached there is a sudden and almost entire change of vegetation. Approaching the marsh we find in most cases, as soon as we reach the moist

ground in the vicinity of its border, the presence of the mosses among the ordinary prairie grass and plants. The moss increases in quantity as the surface becomes more moist, and upon reaching the outer border of the peat we usually find its surface covered with a thick, soft carpet of moss, above and through which the wire-grass grows, hiding the moss from sight at a little distance. As we walk upon the surface of the marsh, if the peat is of considerable depth, we perceive it quaking beneath us, producing a feeling of danger that we may slip through the loose sod into the soft mass below. But of this there is no danger for the sod formed of the moss interwoven with the fibrous roots of the wire-grass is very tough. Cutting through this sod with a sharp spade and lifting out a piece as deep as the spade-blade, we find it a thickly interwoven mass of moss and grass-roots the fibres of which are living upon the top, but they gradually pass downward into the condition of peat, the fineness of the texture of which usually increases with the increasing depth of the marsh.

The real peat vegetation of this region may be said to consist of a single species of moss (*Hypnum*) and another of grass, which goes by the popular name of "wire-grass." It is true that other mosses and other plants contribute largely of their remains to the formation of peat in Northern Iowa; but the remains of the two species mentioned, constitute the bulk of it. Of the two, it is evident that the moss furnishes the greatest amount, although the grass is most conspicuous.

While other plants may and often do grow upon, and enter into the composition of peat, mineral impurities, such as common soil and sand which form the natural habitat of those plants, may from this circumstance be expected to have been diffused in the peat upon which such plants are found growing, by the agency of floods, high winds, etc., because these mineral constituents of soil seem to be indispensable to the growth of those plants, while the moss and wire-grass seem to flourish best upon a surface of pure peat. Thus a very correct judgment may often be formed concerning



PEAT MARSH, 2½ MILES NORTH OF CLEAR LAKE CERRO GORDO Co IOWA, LOOKING W.N.WEST
1868

the character of the peat in one of these marshes, simply by seeing its vegetation, without going upon it. It has been noticed that where the scouring rush, (*Equisetum hyemale*), grows profusely, we do not usually find the peat to be very deep nor very pure, yet none of the marshes are entirely free from this rush.

The peat of the prairie marshes is usually of very good quality, as will be seen by the analyses by Prof. Emery, in another part of this volume. Much of the peat used elsewhere, contains much more ash than that of these marshes will average, notwithstanding the fact that the marshes and the prairies with which they are continuous, are frequently swept by the prairie fires, thus adding the ash of material that does not augment the quantity of the combustible portion of the peat.

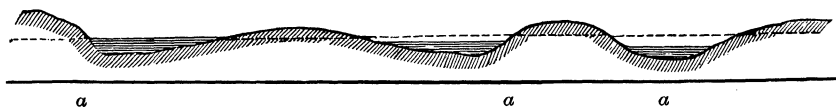
As we stand upon the higher land and look over one of these marshes, stretching sometimes more than a mile away, almost the only vegetation growing upon it which meets the eye is the wire-grass which entirely conceals the moss, and gives the level surface almost the exact appearance of water in the distance, especially when the wind is blowing over the waving grass. Increasing this deceptive appearance, even islands, covered with trees and shrubbery, sometimes occur in the marshes; not true islands now, however, because the land is not now surrounded by water, but by peat. The accompanying sketch of a peat marsh, two and half miles north of the village of Clear Lake, in Cerro Gordo county, gives a good idea of the general appearance of such marshes in Northern Iowa.

Considering the undulatory character of the surface before mentioned, and more fully described in the chapters on Physical Geography, it would be expected that the peat of the smaller marshes would be shallowest, but this, although the rule is not always the case, because the depth depends on the angle of slope of the undulations of the surface. These pond-like marshes are often arranged in series, each occupying a successively lower level, and communicate with each

other by flowing water in the wet seasons, and thence with the little rivulets that form the upper branches of the streams.

The accompanying diagram, (Fig. 91), illustrates this relative position of contiguous marshes:

FIG. 91.



In some parts of the world deposits of peat reach a thickness of thirty or forty feet, but in Iowa there is little reason to expect to find deposits so thick as those, because the depressions before mentioned, in which the peat is formed, are from the very gently undulatory character of the surface, necessarily shallow. While examining the peat marshes of Northern Iowa, their depth was frequently proven, and seldom found to be more than six or eight feet deep of peat, the greater part of them not having that depth of peat, even in their deepest parts.

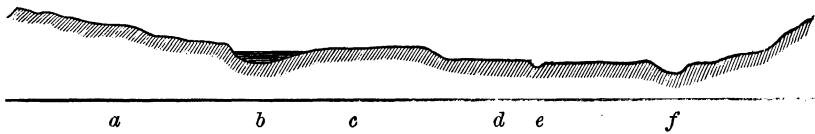
The contour of the slope adjacent to the marsh, often serves as an approximate indication of the depth of the peat. Thus, in the marshes represented in the foregoing diagram, the peat would be found to be deepest, in all the marshes respectively, at *a*. That is, in the two upper ones, it would be found deepest nearer the side which has the steepest slope, while in the lower one it would be found deepest in the middle, because the slopes of each side are equal.

Thus far, no peat whatever has been found west of the Great Watershed which divides the drainage of the Mississippi and Missouri rivers, and none of that yet observed southward from the three northern tiers of counties rests upon the undisturbed surface of the drift, as nearly all of that does which is found above that latitude. Those farther southward, which have a level pond-like character, somewhat similar to those of the drift surface, have always been found to occupy an abandoned, more or less ancient river channel, or

at least to rest upon the surface of modified drift. In such cases, the ancient channel, cut off from the present one, has been kept full of water from oozing springs along its outer border, by which means the necessary constant supply of moisture has been kept up for the growth of peat vegetation and the formation of peat.

The following diagram represents the position of a peat marsh in the valley of Cedar river, near the mouth of Wapsinonock creek, in Pike township, Muscatine county, and well illustrates the relative position of such marshes upon alluvial surfaces.

FIG. 92.

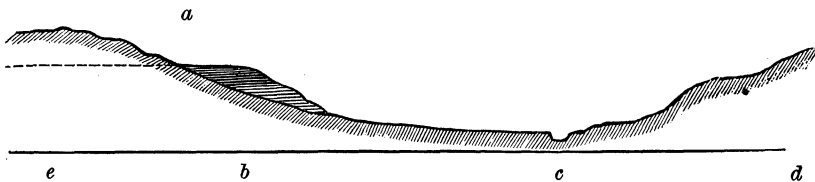


(a) Represents the slope from the upland to the valley. (b), Peat marsh occupying an ancient bed of the river. (c), Ancient flood-plain. (d), Present flood-plain. (e), Bed of Wapsinonock creek. (f), Bed of Cedar river.

The only remaining variety of condition under which peat has been formed in Iowa, so far as yet seen, is the accumulation of it upon a gentle declivity, the gently rounded surface of which being so closely like the gently undulatory slopes around it, that its presence is not readily noticed by the passer by.

The annexed diagram, (Fig. 93), represents one of these accumulations of peat in Linn county, about three miles east of Marion, the county seat:

FIG. 93.



(e) Represents the west slope of the valley of a small creek ; (d), the east slope. (a), The horizontal line along which spring water constantly issues upon the slope, and that has furnished the constant moisture for the formation of the peat deposit (b). The latter does not reach above the line of the issuance of the springs, nor so far down the slope as the creek (c). The spring water issues along the horizontal line, before named, for the distance of about forty rods, and the peat occupies a surface of about twenty-five acres. The cause of the issuance of the springs along that particular horizontal line, is thought to be this: That portion of the hill above the level of the spring line, contains a large proportion of sand which allows the free percolation of the water that falls upon its surface, until it reaches a more impervious stratum occupying the level represented in the diagram by the dotted line, and consequently, flows out at (a).

The vegetation growing upon all peat marshes like this, as well as those which occupy ancient beds of streams, has been found to be more varied than that of the pond-marshes before described. All but a very small proportion of the peat of Iowa is contained in the pond-marshes.

The following estimates of the amount of peat in the different parts of the State is known to be not only incomplete as to the designation of all the counties in which it exists, but is also incomplete as to the real amount which those counties contain that are here named. The object in giving this list is more to direct public attention to the existence in Iowa of this kind of fuel, and to its location, than as a basis for estimating the quantity of such fuel to be found in the State. If such estimates are desired, it is believed safe to double those here given. In these estimates the depth is understood to vary from three to seven feet:

Estimates of the amount of Peat in various parts of Iowa.

COUNTIES.	ACRES.
Cerro Gordo	1,500
Worth	2,000
Winnebago	2,000
Hancock	1,500
Wright	500
Kossuth	700
Dickinson	80
Clinton	250
Muscatine	150

Cedar county contains the first peat marsh of which public notice was given, but it is not at present known how much exists there.

Peat in various parts of the State and also in various marshes in the same region, varies much in quality. This is in part due to the difference in the character of the vegetation from which it has been derived, and in part to the degree of "ripeness," or in other words, to the degree of perfection of the carbonizing process to which the material has reached. Our Iowa peat is almost all of the fibrous variety, so that its quality for fuel is improved by condensation. As to purity, it ranks favorable with that of other countries as well as with that of other parts of our own country, as may be seen by comparing the analyses given by Prof. Emery in his report in another part of this volume. Comparisons of our own peat have been made with that from different parts of Ireland, which show our own to be by no means inferior. It has been found that the peat of our marshes is denser and better towards the bottom of the marsh than near the top. Not that it will burn any more perfectly, but being more compact when dried it is capable of producing a more intense heat.

The peat question being so new to the people of Iowa, and the question of sufficient supplies of fuel so important, it is thought best to treat this subject more in detail than would otherwise be thought necessary.

The manufacture of peat having lately been much discussed in the public prints, the question is often asked by those who find themselves owners of peat-marshes and unacquainted with its use: Is it indispensable that peat must pass through a process of manufacture before it can be burned? If so, is it necessary that a capitalist, with five or ten thousand dollars, should stand between us and a supply of fuel from our own lands; or may we not prepare a good article of fuel from our marshes by our own labor and within our own limited means?

It is *not* indispensable that peat should be subjected to a process of manufacture before it may be burned. It has

been used as fuel in the crude state for hundreds of years. All that is really necessary to do to prepare an abundant supply of fuel ready for use is to drain the marsh by cutting one or more ditches through it. When well drained, strip off the sod with a sharp spade, then with the same spade, or better still with an Irish *slane*, cut the peat into convenient blocks, dry them on the ground, and store them in a dry place for use. This is the simplest method of preparation, but the same peat which thus simply prepared, will answer well all the purposes of ordinary fuel, can be rendered a superior article not only for domestic but for manufacturing purposes, by a condensing process of manufacture. The advantages gained by manufacture are the reduction of both light and compact varieties to a uniform grade, the decrease of bulk so as to require less storage room and an increase of density and consequent value of fuel.

Machines have been constructed for compressing peat into blocks when partially dried, and although the fuel is much improved thereby, it has been found that the compressed blocks quickly disintegrate by absorption of moisture from the atmosphere, and by handling. It is now generally conceded that a *condensing*, and not a compressing process is the proper one to be adopted in the manufacture of peat, and this view is without doubt the correct one. The condensing process consists in grinding the peat while wet in a properly constructed mill, into a smooth pulp, which is then moulded into convenient blocks without great pressure, and dried for use. While these blocks are drying the cellular spaces which existed in the fibrous mass of the crude peat having been broken up by the grinding process, they consequently shrink into compact masses, quite unlike the light crude peat from which they were manufactured. When thoroughly ground and prepared in this manner, the lightest as well as the densest varieties shrink by the natural process of drying alone into uniformly dense masses, denser than blocks of the same peat would be when dry, after having been compressed by the most powerful machinery, without

previous grinding; after which, as has already been shown, compression is not necessary. Machinery for the manufacture of large quantities of peat, necessarily costs considerable sums of money, but since peat is much improved by even an imperfect grinding, it is probable that small machines may be constructed for the purpose, to be turned by hand or horse power, and thus be brought within the means of those who are obliged to perform their own labor.

Peat, thoroughly condensed by machinery, weighs when dry, more than the hard varieties of wood, bulk for bulk, and will, consequently, exceed that wood in heating power. No experiments have been made with our own peat to ascertain its value in relation to our well known varieties of wood, or Iowa coal, but Gysser, a German author, gives the following comparisons of good peat with various German woods and charcoals, equal weights being employed, and air-dry, split beech wood being taken as the standard. Comparison by weight is the only proper method, because that by the cord is merely a question of stowage room, not of heating power.

Gysser's Comparisons of Peat with various Woods.

Beech wood, split, air dry.....	1.00
Peat, condensed by Weber & Gysser's method, with twenty-five per cent. of moisture.....	1.00
Peat, condensed by Weber & Gysser's method, hot dried, with ten per cent. of moisture.....	1.48
Peat-charcoal from condensed peat... ..	1.73
The same peat, simply cut and air dried.....	0.80
Beech charcoal.....	1.90
Summer-oak wood.....	1.18
Birch wood.....	0.95
White pine wood.....	0.72
Alder	0.65
Linden.....	0.65
Red pine.....	0.61
Poplar	0.50

From those and other experiments by Karmarsch, it appears that the different varieties of peat are about equal

in heating power to the different varieties of wood, weight for weight.

A correct estimate of the amount of fuel which a peat marsh may be made to produce, will surprise any one not acquainted with the subject. Taking our fibrous Iowa peat as it will average, it is believed to be a safe estimate that every acre of well drained marsh will yield two hundred and fifty tons of dry fuel for every foot in depth, the marsh being estimated to settle from one-quarter to one-third of its original depth by draining, so great is the amount of water that peat holds within its substance while forming, and after being formed.

Basing estimates upon an annual allowance of thirty tons of peat for each family, one hundred and sixty acres (a quarter section) of peat marsh with peat four feet deep will supply two hundred and thirteen families with fuel, upwards of twenty-five years, even if there should be no further accumulation of peat meantime. This would give ample time to grow forest trees to such an extent, as to place the inhabitants beyond the want of any other fuel, at least for domestic purposes.

As to the value of peat, either pure or in the form of swamp muck, for agricultural purposes, there is no question; and in those portions of Northern Iowa where it exists in considerable quantity there are, as exceptions to the general fertility, many gravelly knolls that will soon become unproductive by cultivation, if not restored by means of some such substances as the marshes afford. Thus even the few sterile spots that exist in the State have a complete remedy immediately at hand.

The value of peat as a fuel in relation to other fuels is a question that has often arisen, and is one always to be decided by the circumstances existing in connection with it. Circumstances give value, both actual and comparative, to all substances, and peat forms no exception to the rule. Therefore, in some regions, although large quantities of it are known to exist, it remains unused. Not that it has no

intrinsic value, but because other fuel to which the inhabitants are already accustomed, is yet abundant and cheap there; and because a supply of it may be obtained at any time of the year, while peat must be prepared and housed in the dry summer months. Even in cases where increasing demand for fuel has carried the price of it above the cost and inconvenience attending the preparation of a supply of peat, so tenaciously do men adhere to established habits in domestic and other affairs, that they continue to pay the increased price without an effort to reduce their expenses in that direction, which they might do by the substitution of peat for the more expensive fuel, but which they allow to remain untouched at their very doors.

Peat will probably always be neglected where good coal and wood are abundant and cheap, but in such a district as the Middle Region of Northern Iowa, the surface of which is mostly fertile prairie and, of course, destitute, to a great extent of wood fuel, and also at considerable distance from the coal-field, peat has a local value that can never be questioned. At present, it is true, the sparseness of the population keeps the little timber that exists there at so low a price that the peat is not yet used to any extent, but its value will appear as population increases.

It may well be questioned whether peat in Iowa will prove profitable to those who may attempt to speculate in it, or make the business of supplying it to the trade a basis of private fortunes, as has been done with coal, but its existence in a beautiful, fertile, and healthful region, where other kinds of fuel are scarce or wanting, is a public boon, the value of which is not in danger of being over estimated.

The opinion has prevailed, to some extent, that little or no peat has been formed in limestone regions, or in regions or in marshes whose waters hold lime in solution. The facts observed in Northern Iowa, seem to show that the presence of lime has no influence in preventing or checking the formation of peat, for all the waters of Iowa, even those of the wells and ponds in the drift alone, contain much lime; and,

in some cases, the marshes are bordered by limestone ledges. In another chapter, Prof. Emery gives an analysis of water from a marsh in Cerro-Gordo county, which was bordered upon both sides by limestone ledges. The water, as might be expected, contains much lime, and yet the marsh is a large one, the peat abundant and pure, and the water analyzed was obtained in the wet season.

Fossil Peat has been discovered at two or three localities in Iowa, which are mentioned in the chapter on "Surface Deposits."

2. PETROLEUM.

Although petroleum, in various forms and under various names, has been known to the world for centuries, it is only within the last few years that it has come into general use as an illuminating material. For a few years previous to the discovery of petroleum in such immense quantities in Northwestern Pennsylvania, an illuminating oil distilled from coal, and chemically almost identical with that distilled from petroleum, was in very general use; but the cheapness and abundance of the latter soon caused the production of the other to be discontinued. Following those discoveries in Pennsylvania, large deposits of it were also found in Virginia, Ohio, and Canada, upon which speculation and excitement rapidly extended over the whole country, reaching our own State where it had hardly begun to subside at the time of the present organization of the Geological Survey. Several companies were formed in different parts of the State, principally in the coal region along the valley of the Des Moines river. Their operations were mainly confined to leasing the lands from the owners, not taking possession of them, but agreeing to commence search for mineral substances, especially petroleum and coal, within a specified time, and to pay the owners a certain per centage of the products of their discoveries. A few borings were made and although discoveries of petroleum were frequently announced in the public prints, no satisfactory evidence has been

obtained that any quantity whatever has been discovered within the limits of our commonwealth, except what has been brought hither by artificial means.

An examination of the geological structure of the State, as given on previous pages of this report, together with the most reasonable theory of the origin of petroleum, it is believed, will warrant the conclusion that this substance, in paying quantities, will never be found within the borders of Iowa. The theory referred to is that petroleum has had its origin in either marine or terrestrial vegetation, the remains of which have become buried within the strata of the earth and there undergone a metamorphism, so to speak, which has resulted in the production of petroleum. Where the real source of petroleum in any but very small quantities has been ascertained, it has been found to be in carbonaceous shales, the petroleum having been produced from the large proportion of carbonaceous matter they contain; or in bituminous shales, as the carbonaceous matter sometimes exists in the shales in the form of bitumen, from which petroleum may be, and often is artificially distilled. Other strata resting upon these carbonaceous shales, often at a great depth, exert an immense pressure upon them, in consequence of which, the contained petroleum rises into, and is often obtained from those strata in which it really did not originate, particularly if the overlying strata be porous like some varieties of sandstone, for example. This rising of the petroleum towards the surface is doubtless accelerated in some cases by the flow of water into cavities in the strata previously occupied by petroleum the latter being lighter the former rises upon it.

The bituminous or carbonaceous matter of such shales form so inconsiderable a proportion of the mass, it would of course require deposits of great thickness to produce any considerable quantities of petroleum. Deposits of such shales having a very great thickness, are known to exist beneath that part of Pennsylvania, where petroleum is found in such great quantities. They are, however, there covered by another formation composed largely of sandstone, but that

sandstone formation thins out to the northward, and the shales come up to the surface from beneath it the State of New York.

It was formerly believed, even by all geologists, that coal existed among strata of one geological age alone, but this opinion is now known to be erroneous. So, also, since coal-oil and the oil distilled from petroleum, are essentially identical, it has been popularly believed that all petroleum had its origin in connection with coal. Some petroleum has been found among coal-bearing strata, but the largest deposits of petroleum yet known have no such connection.

Those of the Caucasus, near the Caspian Sea, are of Tertiary age, and those of our own country, are almost all of Devonian age. In none of these cases is any coal known to exist in connection with or near them, and in many of the cases, as for example, the Pennsylvania deposits, it is certain that the petroleum has no connection whatever with coal, although the latter is found in the same region.

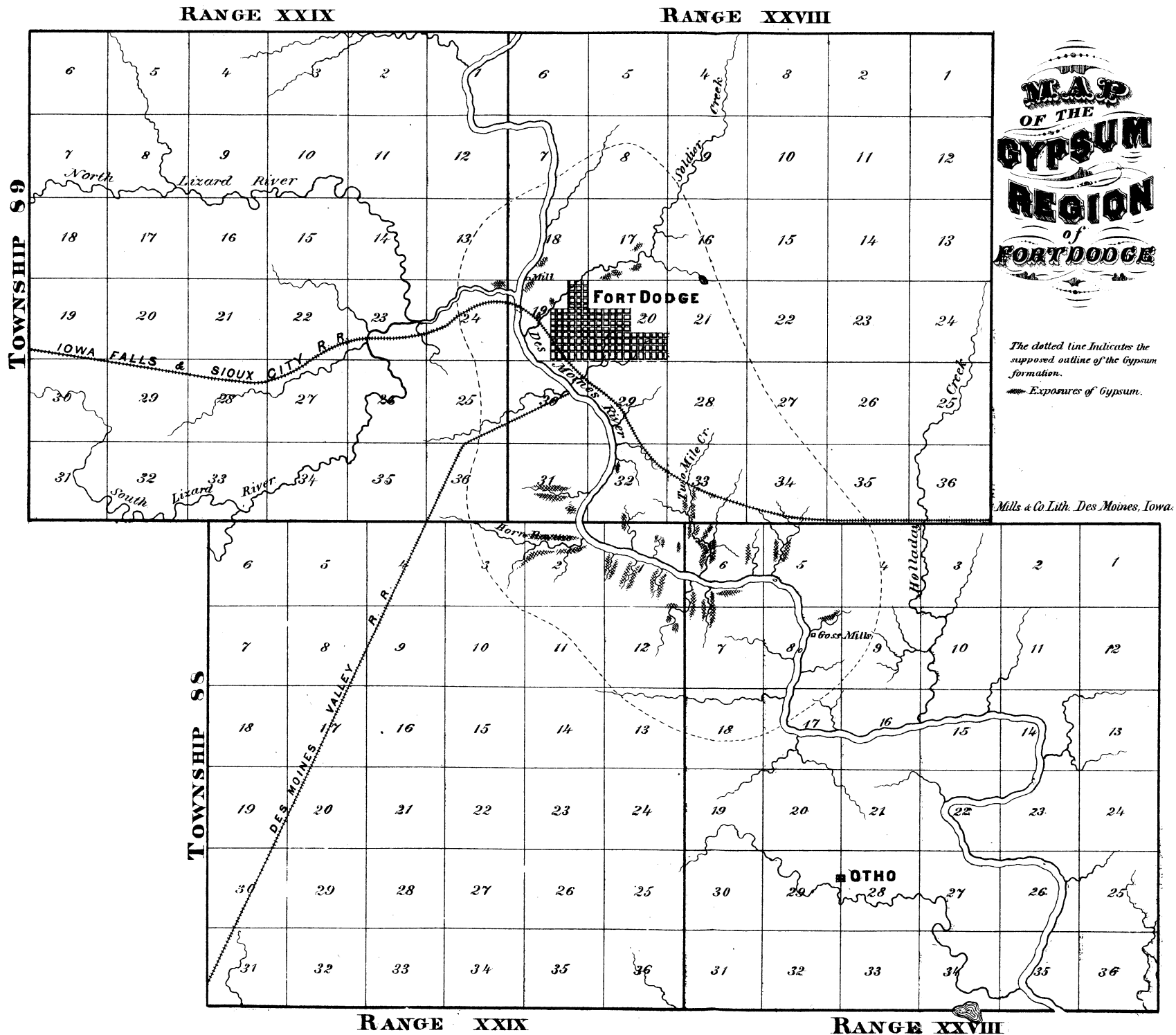
Now applying these general remarks upon the origin of petroleum to the question of its existence in Iowa, we have to inquire whether any strata underlie its surface, which possess such a character as would reasonably lead one to suppose they might contain petroleum in any but minute quantities. By reference to the lithograph section of the formations of the State, on a previous page, and to the accompanying description of the rocks it represents, it will be seen that no strata containing any considerable proportion of carbonaceous matter, exist among them, except those of the Middle and Lower coal-measures. The Maquoketa shales are known at times to contain a small proportion of bituminous matter, but too little, it is believed, to produce an amount of petroleum sufficient to saturate the shales at any point. Actual examinations of the coal-field have thus far shown the existence of no petroleum, even in the minutest quantity, not so much indeed as has been observed in rocks of older date where faint traces have been detected. For example, the columnar calc spar in the Devonian strata near

Waverly, in Bremer county, contains a sufficient amount to give off its peculiar fetid odor when struck with a hammer. Most of the Upper Silurian strata at Anamosa, and other places in Iowa, will also give off a more or less distinct odor under the same circumstances, but from the very nature of the case it could not be expected that petroleum could be collected from any of these strata. Mr. Worthen, the State Geologist of Illinois, reports that strata of the age of the Niagara limestone, near Chicago, contains so much petroleum that samples of it may be collected in some of the quarries. Mr. H. T. Woodman, of Dubuque, has also shown me some shale from the Trenton limestone formation in Southwestern Wisconsin, that contains so much bituminous substance as to blaze freely, and emit the peculiar odor of petroleum when ignited. Both these formations extend beneath the surface of our State, and may doubtless be reached by boring down through those that overlie them, but they are evidently too thin and unimportant to yield any but the merest traces of petroleum, and it is therefore believed that any hope of finding it in paying quantities in Iowa is not well founded.

Considering the fact that our own State will probably never supply us with petroleum, and in view of the great superiority of the illuminating oil distilled from it over all other portable illuminating materials, the question naturally arises whether the present sources of supply will remain constant, so that there may be no future necessity of resuming the use of the discarded illuminating materials, or of resorting to some other. The following facts will tend to allay solicitude upon this subject.

Although individual wells in the different oil regions from which we now derive our supplies, are not now yielding as much as they did at one time, the aggregate supply is as great, if not greater, than ever before. There is a large and rich petroleum region in the Caucasus, near the Caspian sea, and another in the valley of the river Irawaddy, in Birmah, each of which is probably equal to the Pennsylvania oil

region. Besides these, several minor regions are known and many others will, doubtless, yet be discovered. Should all these sources fail, which is not to be expected, the manufacture of the same kind of oil from coal may be resumed with profit to the manufacturer, and yet the consumer be supplied with a cheaper and better illuminator than was in general use a dozen years ago.



CHAPTER II.

GYPSUM AND OTHER SULPHATES OF THE ALKALINE EARTHS.

The only deposits of the sulphates of the alkaline earths of any economic value in Iowa, are those of gypsum at and in the vicinity of Fort Dodge, in Webster county. All others are small and unimportant.

1. THE FORT DODGE GYPSUM DEPOSIT.

The large deposit of gypsum near Fort Dodge is one of the most important yet discovered in the United States, and is the only one of any economic value known to exist, not only in Iowa, but in any of the adjoining States. This fact alone gives it great value, besides which, it possesses great scientific interest. In view of this, and the fact that former accounts given to the public concerning this region have been incomplete, I have devoted considerable time to its examination, in company with Prof. St. John, and the following pages are the result of our joint labors.

The deposit occupies a nearly central position in Webster county, the Des Moines river running nearly centrally through it, along the valley-sides of which the gypsum is seen in the form of ordinary rock cliffs and ledges, and also occurring abundantly in similar positions along both sides of the valleys of the smaller streams and of the numerous ravines coming into the river valley.

The most northerly known limit of the deposit is at a point

near the mouth of Lizard creek, a tributary of the Des Moines river, and almost adjoining the town of Fort Dodge. The most southerly point at which it has been found exposed, is about six miles, by way of the river, from this northerly point before mentioned. Our knowledge of the width of the area occupied by it is limited by the exposures seen in the valleys of the small streams and in the ravines which come into the river valley within the distance mentioned. As one goes up these ravines and minor valleys, the gypsum becomes lost beneath the overlying drift. There can be no doubt that the different parts of this deposit, now disconnected by the valleys and ravines having been cut through it, were originally connected as a continuous deposit, and there seems to be as little reason to doubt that the gypsum still extends to considerable distance on each side of the valley of the river beneath the drift which covers the region to a depth of from twenty to sixty feet.

The country round about this region has the prairie surface approximating a general level, which is so characteristic of the greater part of the State, and which exists irrespective of the character or geological age of the strata beneath, mainly because the drift is so deep and uniformly distributed that it frequently, almost alone, gives character to the surface. The valley-sides of the Des Moines river, in the vicinity of Fort Dodge, are somewhat abrupt, having a depth there from the general level of the upland of about one hundred and seventy feet, and consequently presents somewhat bold and interesting features in the landscape.

As one walks up and down the creeks and ravines which come into the valley of the Des Moines river there, he sees the gypsum exposed on either side of them, jutting out from beneath the drift in the form of ledges and bold quarry fronts, having almost the exact appearance of ordinary limestone exposures, so horizontal and regular are its lines of stratification, and so similar in color is it to some varieties of that rock. The accompanying sketch gives a view of one of the principal quarries now opened on Two Mile creek, a couple of miles below Fort Dodge.

The reader will please bear in mind, that the gypsum of this remarkable deposit does not occur in "heaps" or "nests," as it does in most deposits of gypsum in the States farther eastward, but that it exists here in the form of a regularly stratified, continuous formation, as uniform in texture, color, and quality throughout the whole region, and from top to bottom of the deposit as the granite of the Quincy quarries is. Its color is a uniform gray, resulting from alternating, fine horizontal lines of nearly white, with similar lines of darker shade. The gypsum of the white lines is almost entirely pure, the darker lines containing the impurity. This is at intervals barely sufficient in amount to cause the separation of the mass upon those lines into beds or layers, thus facilitating the quarrying of it into desired shapes. These bedding surfaces have occasionally a clayey feeling to the touch, but there is nowhere any intercalation of clay or other foreign substance in a separate form. The deposit is known to reach a thickness of thirty feet at the point represented in the sketch, but although it will probably be found to exceed this thickness at some other points, at the natural exposures, it is seldom seen to be more than from ten to twenty feet thick.

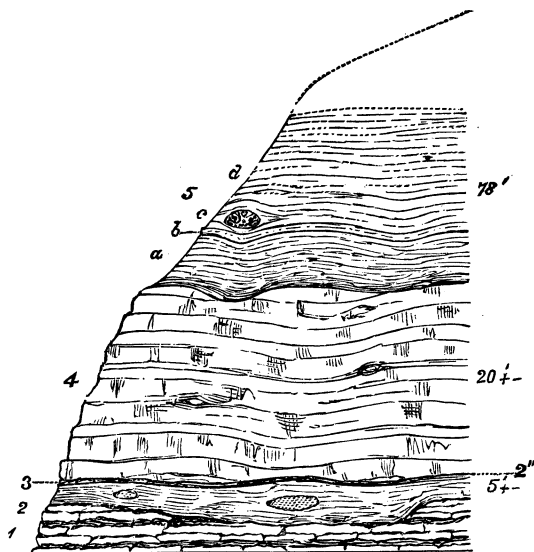
Since the drift is usually seen to rest directly upon the gypsum, with nothing intervening, except at a few points where traces appear of an overlying bed of clayey material without doubt of the same age as the gypsum, the latter probably lost something of its thickness by mechanical erosion during the glacial epoch; and it has, doubtless, also suffered some diminution of thickness since then by solution in the waters which constantly percolate through the drift from the surface. The drift of this region being somewhat clayey, particularly in its lower part, it has doubtless served in some degree as a protection against the diminution of the gypsum by solution in consequence of its partial imperviousness to water. If the gypsum had been covered by a deposit of sand instead of the drift clays, it would no doubt have long since disappeared by being dissolved in the water that would have constantly

reached it from the surface.* Water merely resting upon it would not dissolve it away to any extent, but it rapidly disappears under the action of running water. Where little rills of water at the time of every rain run over the face of an unused quarry from the surface above it, deep grooves are thereby cut into it, giving it somewhat the appearance of melting ice around a waterfall. The fact that gypsum is now suffering a constant, but of course, a very slight diminution, is apparent in the fact that the springs of the region contain more or less of it in solution in their waters. An analysis of water from one of these springs will be found in Professor Emery's report on another page.

Besides the clayey beds that are sometimes seen to rest upon the gypsum, there are occasionally others seen beneath them that are also of the same age, and not of the age of the coal-measure strata upon which they rest. The following

FIG. 94.

Section at Cummin's Quarry.



* Three parts by weight of gypsum are soluble in one thousand parts by weight of distilled water.



Mills & Co Lith. Des Moines.

GYPSUM QUARRIES NEAR FORT DODGE, IOWA, 1868.

diagram illustrates an exposure of gypsum, together with the associated strata, as seen at Cummin's quarries, in the valley of Soldier creek, immediately north of Fort Dodge:

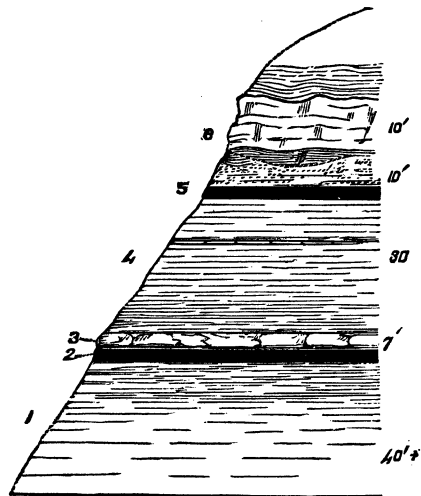
No. 5.	Variegated clays and arenaceous shales.....	18	feet.
No. 4.	The ordinary gray gypsum.....	20	feet.
No. 3.	Grayish sandy clay.....	$\frac{1}{8}$	foot.
No. 2.	Ferruginous clayey bed, containing nodular masses of gray and brown sandstone.....	3	feet.
No. 1.	St. Louis limestone.....	5	feet.
Total		$46\frac{1}{8}$	feet.

All of the strata represented in the diagram (Fig. 94.) from two to five inclusive, are referred to the same age, that is, the age of the gypsum, whatever that may be. It is true that the horizontal laminæ of the gypsum layers do not conform to the laminæ of the clays that underlie and overlie them; but this is, doubtless, due to the gradual and slow wasting away of the gypsum upon both the upper and under surfaces of the deposit, while the clayey laminæ are unchanged except by slight distortion from settling, occasioned by the solution and removal of the gypsum.

Allowing all these strata except No. 1, to be of the same age, it will be seen that they rest directly upon the St. Louis (Sub-carboniferous) limestone in the valley of Soldier creek; while at all the other localities in the region of the gypsum and its associated strata—when the latter are seen, which is not often—rest upon the strata of the Lower coal-measures. It rests unconformably upon these strata as may be seen by their varying thickness between it and the St. Louis limestone. This thickness amounts to full one hundred feet in the southern part of the region; and taking the maximum thickness of all the recognized beds of the Lower coal-measures with the same limits it amounts to much more.

The following diagram represents a section measured at Goss' mill, six miles below Fort Dodge, which point is the most southerly limit of the gypsum region as now known :

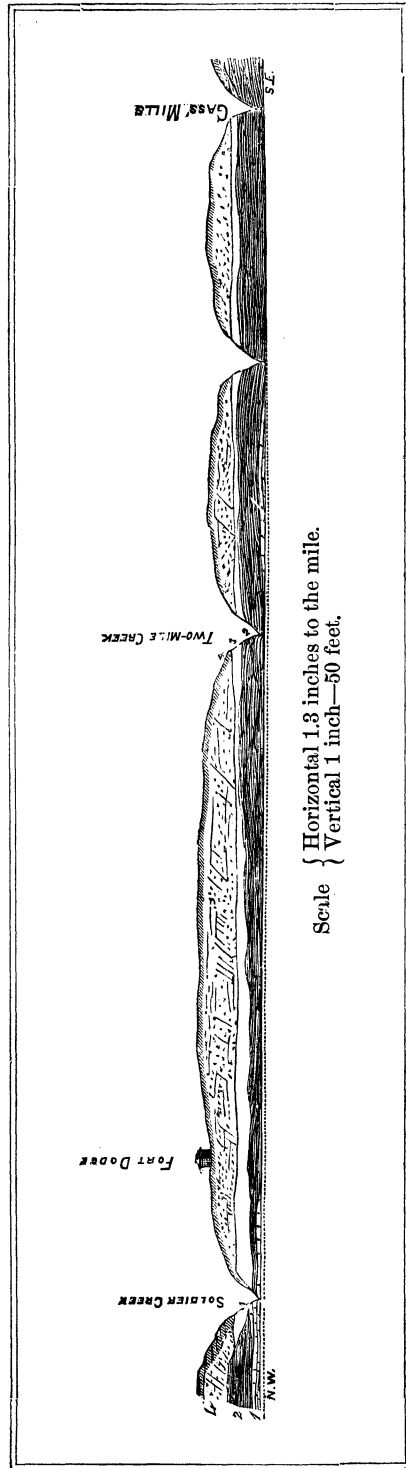
FIG. 95.
Section near Goss' Mill.



No. 6.	Gypsum, with its associated sandy and clayey shales..	10	feet.
No. 5.	Coal.....	21½	feet.
No. 4.	Shales.....	30	feet.
No. 3.	Sandstone.....	3	feet.
No. 2.	Impure coal.....	2	feet.
No. 1.	Dark colored shales.....	40	feet.
Total.....		87½	feet.

The coal, No. 5, is regarded as the same bed as No. 15, of the general section of Carboniferous strata, given in the chapter on the geology of Webster county, and coal-bed, No. 2, of this diagram, is regarded as the same as No. 12, of that section. No. 5 has a bed of sandstone of variable thickness above it, which is represented but not numbered in the diagram. All the strata beneath No. 6, belong to the Lower coal-measures, all of which are absent at Cummin's quarry, in the valley of Soldier creek, six miles northward from Goss' mill. The diagram, Fig. 96, represents a longitudinal section along the Des Moines river, from Soldier creek to Goss' mill, and well illustrates the relations of the Gypsum. Coal-measure and Sub-carboniferous strata to each other.

Fig. 96.
LONGITUDINAL SECTION FROM SOLDIER CREEK TO GOSS' MILL.



Longitudinal Section from Soldier creek to Goss' mill.

The dotted line represents approximately the actual level.

The base line of the section is the level of the Des Moines river.

No. 1. St. Louis, (Sub-carboniferous) limestone.

No. 2. Lower coal measures.

No. 3. Gypsum deposits.

No. 4. Drift.

It is an interesting fact that all these formations and deposits are unconformable with each other, although each are so slightly disturbed.

Age of the Gypsum Deposit. In neither the gypsum nor the associated clays has any trace of any fossil remains been found, nor has any other indication of its geological age been observed, except that which is afforded by its stratigraphical relations; and the most that can be said with certainty is that it is newer than the coal-measures, and older than the drift. The indications afforded by the stratigraphical relations of the gypsum deposit of Fort Dodge are, however, of considerable value.

As already shown, it rests in that region directly and unconformably upon the Lower coal-measures; but going southward from there, the whole series of coal-measure strata from the top of the Sub-carboniferous group to the Upper coal-measures, inclusive, can be traced without break or unconformability. The strata of the latter also may be traced in the same manner up into the Permian rocks of Kansas; and through this long series, there is no place or horizon which suggests that the gypsum deposit might belong there.

Again, no Tertiary deposits are known to exist within or near the borders of Iowa to suggest that the gypsum might be of that age; nor are any of the palæozoic strata newer than the Sub-carboniferous unconformable upon each other as the other gypsum is unconformable upon the strata beneath it. It therefore seems, in a measure conclusive, that the gypsum is of Mesozoic age, perhaps older than the Cretaceous.

Lithological Origin. As little can be said with certainty concerning the lithological origin of this deposit as can be said concerning its geological age, for it seems to present itself in this relation, as in the former one, as an isolated fact. None of the associated strata show any traces of a double decomposition of preëxisting materials, such as some have supposed all deposits of gypsum to have resulted from. No considerable quantities of oxide of iron, nor any trace of native sulphur have been found in connection with it; nor has any salt been found in the waters of the region. These substances are common in association with other gypsum deposits, and are regarded by some persons as indicative of the method of or resulting from their origin as such. Throughout the whole region the Fort Dodge gypsum has the exact appearance of a sedimentary deposit. It is arranged in layers like the regular layers of limestone, and the whole mass from top to bottom is traced with fine horizontal laminæ of alternating white and gray gypsum, parallel with the bedding surfaces of the layers, but the whole so intimately blended as to form a solid mass. The darker lines contain almost all the impurity there is in the gypsum, and that impurity is evidently sedimentary in its character. From these facts, and also from the further one that no trace of fossil remains has been detected in the gypsum, it seems not unreasonable to entertain the opinion that the gypsum of Fort Dodge originated as a chemical precipitation in comparatively still waters which were saturated with sulphate of lime and destitute of life; its stratification and impurities being deposited at the same time as clayey impurities which had been held suspended in the same waters.

Physical Properties. Much has already been said of the physical properties or characters of this gypsum, but as it is so different in some respects from that of other deposits there are yet other matters worthy of mention in connection with those. According to the results of analyses by Prof. Emery, given on another page of this report, the ordinary gray gypsum contains only about eight per cent of impurity;

and it is probable that the average impurity for the whole deposit will not exceed that proportion, so uniform in quality is it from top to bottom and from one end of the region to the other.

When it is remembered that plaster for agricultural purposes is sometimes prepared from gypsum that contains as much as thirty per cent of impurity, it will be seen that ours is a very superior article for such purposes. The impurities are also of such a character that they do not in any way interfere with its value for use in the arts. Although the gypsum rock has a gray color, it becomes quite white by grinding, and still whiter by the calcining process necessary in the preparation of plaster of paris. These tests have all been practically made in the rooms of the Geological Survey, and the quality of the plaster of paris still further tested by actual use and experiment. No hesitation, therefore, is felt in stating that the Fort Dodge gypsum is of as good quality as any in the country, even for the finest uses.

In view of the bounteousness of the primitive fertility of our Iowa soils, many persons forget that a time may come when Nature will refuse to respond so generously to our demands as she does now, without an adequate return. Such are apt to say that this vast deposit of gypsum is valueless to our Commonwealth except to the small extent that it may be used in the arts. This is undoubtedly a short-sighted view of the subject, for the time is even now rapidly passing away, when a man may purchase a new farm for less money than he can re-fertilize and restore the partially wasted primitive fertility of the one he now occupies. There are farms even now in a large part of the older settled portions of our State that would be greatly benefitted by the proper application of plaster, and such areas will continue to increase until it will be difficult to estimate the value of the deposit of gypsum at Fort Dodge. It should be remembered, also, that the inhabitants of an extent of country adjoining our State more than three times as great as its own area, will

find it more convenient to obtain their supplies from Fort Dodge than from any other source.

For want of direct railroad communication between this region and other parts of the State, the only use yet made of the gypsum by the inhabitants is for the purposes of ordinary building-stone. It is so compact that it is found to be comparatively unaffected by the frost, and its ordinary situation in walls of houses is such that it is protected from the dissolving action of water, which can at most reach it only from occasional rains, and the effect of these is too slight to be perceived after the lapse of several years.

One of the citizens of Fort Dodge, Hon. John F. Duncombe, built a large, fine residence of it in 1861, the walls of which appear as unaffected by exposure and as beautiful as they were when first erected. It has been so long and successfully used for building-stone by the inhabitants that they now prefer it to the limestone of good quality, which also exists in the immediate vicinity. This preference is due to the cheapness of the gypsum as compared with the stone. The cheapness of the former is largely due to the facility with which it is quarried and wrought. Several other houses have been constructed of it in Fort Dodge, including the depot building of the Dubuque and Sioux City Railroad. The company have also constructed a large culvert of the same material to span a creek near the town, limestone only being used for the lower courses which come in contact with the water. It is a fine arch, each stone of gypsum being nicely hewn, and it will doubtless prove a very durable one. Many of the sidewalks in the town are made of the slabs or flags of gypsum which occur in some of the quarries in the form of thin layers. They are more durable than their softness would lead one to suppose. They also possess an advantage over stone in not becoming slippery when worn.

The method adopted in quarrying and dressing the blocks of gypsum is peculiar, and quite unlike that adopted in similar treatment of ordinary stone. Taking a stout augur-bit of an ordinary brace, such as is used by carpenters, and

filing the cutting parts of it into a peculiar form, the quarryman bores his holes into the gypsum quarry for blasting in the same manner and with as great facility as a carpenter would bore hard wood. The pieces being loosened by blasting, they are broken up with sledges into convenient sizes, or hewn into the desired shapes by means of hatchets or ordinary chopping axes, or cut by means of ordinary wood-saws. So little grit does the gypsum contain that these tools, made for working wood, are found to be better adapted for working the former substance, than those tools are which are universally used for working stone.

2. MINOR DEPOSITS OF SULPHATE OF LIME.

Besides the great gypsum deposit of Fort Dodge, sulphate of lime in the various forms of fibrous gypsum, selenite, and small, amorphous masses, has also been discovered in various formations in different parts of the State, including the coal-measure shales near Fort Dodge, where it exists in small quantities, quite independently of the great gypsum deposit there. The quantity of gypsum in these minor deposits is always too small to be of any practical value, and frequently minute. They usually occur in shales and shaly clays, associated with strata that contain more or less sulphuret of iron, (iron pyrites). Gypsum has thus been detected in the Coal-measures, the St. Louis limestone, the Cretaceous strata, and also in the lead-caves of Dubuque. In most of these cases it is evidently the result of double decomposition of iron pyrites and carbonate of lime, previously existing there; in which cases the gypsum is of course not an original deposit as the great one of Fort Dodge is supposed to be.

The existence of these comparatively minute quantities of gypsum in the shales of the coal-measures and the Sub-carboniferous limestone which are exposed within the region of, and occupy a stratigraphical position beneath the great gypsum deposit, suggests the possibility that the former may have originated as a precipitate from percolating

waters, holding gypsum in solution which they had derived from that deposit in passing over or through it. Since, however, the same substance is found in similar small quantities and under similar conditions in regions where they could have had no possible connection with that deposit, it is believed that none of those mentioned have necessarily originated from it, not even those that are found in close proximity to it.

The gypsum found in the lead caves is usually in the form of efflorescent fibres, and is always in very small quantity. In the Lower coal-measure shale near Fort Dodge, a small mass was found in the form of an intercalated layer, which had a distinct fibrous structure, the fibres being perpendicular to the plane of the layer. The same mass had also distinct, horizontal planes of cleavage at right angles with the perpendicular fibres. Thus, being more or less transparent, the mass combined the characters of both fibrous gypsum and selenite. No anhydrous sulphate of lime (*Anhydrite*) has been found in connection with the great gypsum deposit, nor elsewhere in Iowa, so far as yet known.

3. SULPHATE OF STRONTIA. (*Celestine*.)

The only locality at which this interesting mineral has yet been found in Iowa, or so far as is known, in the great valley of the Mississippi, is at Fort Dodge. It occurs there in very small quantity in both the shales of the Lower coal-measures and in the clays that overlie the gypsum deposit and which are regarded as of the same age with it. The first is just below the city, near Rees' coal-bank and occurs as a layer intercalated among the coal-measure shales, amounting in quantity to only a few hundred pounds weight. The mineral is fibrous and crystalline, the fibres being perpendicular to the plane of the layer. Breaking also with more or less distinct horizontal planes of cleavage it resembles, in physical characters the layer of fibro-crystalline gypsum before mentioned. Its color is light blue, is transparent and shows crystalline

facets upon both the upper and under surfaces of the layer; those of the upper surface being smallest and most numerous. It breaks up readily into small masses along the lines of the perpendicular fibres or columns. The layer is probably not more than a rod in extent in any direction and about three inches in maximum thickness. Apparent lines of stratification occur in it, corresponding with those of the shales which imbed it.

The other deposit was still smaller in amount, and occurred as a mass of crystals imbedded in the clays that overlie the gypsum at Cummins' quarry in the valley of Soldier creek, upon the north side of town. The point at which they occurred, is shown at (c) in the section at Cummins' quarry, on a previous page. The mineral is in this case nearly colorless, and but for the form of the separate crystals would closely resemble masses of impure salt. The crystals are so closely aggregated that they enclose but little impurity in the mass, but in almost all cases their fundamental forms are obscured. This mineral has almost no real practical value, and its occurrence, as described, is interesting only as a mineralogical fact.

4. SULPHATE OF BARYTA.—(*Barytes, Heavy Spar*).

This mineral has been found in only minute quantities in Iowa. It has been detected in the coal-measure shales of Decatur, Madison, and Marion counties; the Devonian limestone of Johnson and Bremer counties and in the lead caves of Dubuque. In all these cases, it is in the form of crystals or small crystalline masses.

5. SULPHATE OF MAGNESIA.—(*Epsomite*).

Epsomite, or native epsom salts, having been discovered near Burlington, we have thus recognized in Iowa all the sulphates of the Alkaline earths of natural origin; all of them, except the sulphate of lime, being in very small quantity. Even if the sulphate of magnesia were produced

in nature, in large quantities, it is so very soluble that it can accumulate only in such positions as afford it complete shelter from the rains or running water. The epsomite mentioned, was found beneath the overhanging cliffs of Burlington limestone, near Starr's mill, which are represented in the sketch upon another page, illustrating the Sub-carboniferous rocks. It occurs in the form of efflorescent encrustations upon the surfaces of stones and in similar small fragile masses among the fine debris that has fallen down beneath the overhanging cliff. The projection of the cliff over the perpendicular face of the strata beneath amounts to near twenty feet at the point represented in the sketch. Consequently the rains never reach far beneath it from any quarter. The rock upon which the epsomite accumulates is an impure limestone containing also some carbonate of magnesia, together with a small proportion of iron pyrites in a finely divided condition. It is doubtless by double decomposition of these that the epsomite results. By experiments with this native salt in the office of the Survey, a fine article of epsom salts was produced, but the quantity that might be annually obtained there would amount to only a few pounds, and of course is of no practical value whatever, on account of its cheapness in the market.

CHAPTER III.

BUILDING MATERIALS, METALS, AND MISCELLANEOUS SUBSTANCES.

1. BUILDING AND ORNAMENTAL STONE.

Nothing like a complete report upon the building stone of the State can be given at present because sufficient time and labor could not be bestowed upon that subject. Only the more important of the quarries yet examined are here referred to and their products described, the remainder being omitted with the hope of an opportunity to introduce their description into a future report. The quarries that have become most noted and from which large supplies of good material for distant transportation may be obtained are those of Anamosa, Johnson county, Le Claire, Le Grand, Keokuk, and Farley. These, besides the intrinsic value of their stone, have the additional advantage of location either upon an important line of railway or upon the banks of the Mississippi river. There are, of course, hundreds of other quarries in the State that are locally almost invaluable. These have been largely noticed in the detailed geology of the regions already described in other parts of this report, but the object here is only to present an outline description of those quarries and their stone from which material may be obtained for our public and other important buildings.

The report of the Chemist contains the result of analyses of specimens from the majority of these quarries which will be found useful in deciding upon their relative value. Other

practical tests of their relative properties, such as resistance to crushing force and corrosive disintegration have not been made for want of the proper appliances. As to the results of the action of the atmosphere and frost upon them we only know that in case the material has been selected with care, from any of the quarries named, it has shown no indications of destructive fracture or disintegration during the few years they have been tested. Whenever the legislature may decide to order the erection of a State-House the material will doubtless be taken from one of the quarries here named, if procured within the limits of the State. The most that can now be said concerning the fitness of these Iowa stones for such a purpose is that there is no reason to doubt that a sufficient amount of material may be obtained from the quarries at either of these places to erect a series of public buildings of which every citizen of Iowa may well be content. There are, however, many layers in these quarries, as there are in all quarries, which contain stone entirely unsuited to such structures however valuable they may be for other purposes.

2. JOHNSON COUNTY QUARRIES.

These are the quarries from which the best of the stone was obtained of which the old State-House was built at Iowa City, the former capital of Iowa. They are located on the right bank of the Iowa river, in Penn township, and about eight miles northwestward from Iowa City. The strata are of Devonian age, and the best ever opened in strata of that age in the State. In composition the stone is common limestone, with a small proportion of carbonate of magnesia in some of its layers. Its color is a uniform light gray, and its texture is that called "tough" by quarrymen; that is, it has not that compact and brittle texture so common with the limestone of Devonian age, in the Mississippi valley. This quality renders it very valuable as a building material, since stone of such texture is not so readily affected by frost and exposure, as the more compact and fine grained limestones

usually are. The unchanged condition of this stone, either in character or color, during the thirty years that it has been tested in the old State-House, and other buildings in the vicinity, affords the most complete practical proof of its great value. This test has been especially severe from the fact that the stone has been placed in the walls just where the surface of the ground meets them, as well as in equally exposed places.

None of the stone is suitable for polishing, but its great value lies in its suitability for dressing for use in massive structures, and for the more important parts of ordinary masonry.

The layers are from a few inches to two or three feet in thickness, and the whole, over a large space, having but a slight covering of earth, the quarrying of the rock may be done with great facility; but the quarries have, of late years, been much neglected on account of being four or five miles from a railroad, or other abundant means of transportation.

3. ANAMOSA QUARRIES.

These quarries are in the Upper Silurian limestone, which everywhere in Iowa, is magnesian, and which usually lacks uniformity in both stratification and texture, but within an area containing apparently about two square miles, its stratification possesses wonderful uniformity, and its texture is quite homogeneous. Within this area several quarries have been opened, but the principal ones are located immediately upon the left bank of the Wapsipinicon, three miles westward from Anamosa. These are now wrought by Messrs Philip Haines and Co., and Krause, Shaw, Weaver, and Co. The track of the Dubuque Southwestern Railway runs through both of them, and thus furnishes ready means for transportation. The exposures here have a vertical thickness from the water's edge to the top of the bluff, of about ninety feet, nearly all of which is valuable building stone. Within a mile farther up the valley, and upon the

line of the same railroad, Messrs. Parsons and Webb, and Mr. H. Dearborn have opened quarries in the same strata; but the first two named are much the most extensive and important. They also embrace the whole vertical thickness of all the strata exposed in the region, and consequently embrace all varieties of quality which the stone of the region presents. For these reasons reference will be made to these quarries alone, which are, indeed, only one continuous exposure, the strata of which can be traced continuously from one quarry to the other.

The stone is fine grained, non-crystalline, very uniformly and horizontally bedded, and in some parts of the vertical range of the strata, they split readily into thin layers, varying from half an inch to an inch or two in thickness upon long exposure to the atmosphere and frost. The slabs thus produced have a wonderful uniformity of thickness, and some of them have their surfaces as smooth and uniform as those of a board just from the planing machine. These uniform lines of stratification are more or less apparent throughout the entire exposure of strata here, so that the layers of many of them may be readily split into slabs after they are removed from the quarry. Some of the layers, however, cannot be so split, and it is these that will be found most suitable for massive structures. From those layers which are capable of being split, excellent shales of suitable thickness and of any desired size may be obtained. Some of the layers will furnish blocks four feet in thickness, if desired; and from very many of them are obtained almost perfect ashlar for caps, sills, water-tables, store front columns, etc. The bedding surfaces are so smooth and true in many instances as not to require to be touched with a chisel. From fifteen to twenty feet of the rock from the base of the exposure, is more porous in texture than that near the top, but they are harder, heavier, and doubtless fully as durable. The stone of the upper layers is quite hard enough for any ordinary use, and they also harden a little upon exposure after being quarried. The weight per cubic foot of the stone

of these layers, according to Mr. Haines, is one hundred and forty pounds, while that for the lower layers is one hundred and sixty pounds, the stone being perfectly dry in both cases. A striking peculiarity of these layers is, that nowhere from top to bottom, are there any clayey or other partings between them, but the solid and homogeneous stone rests, layer upon layer, their bedding surfaces fitting almost as closely as leaves in a book. This is of great advantage in their use, even in common walls, for the stones may be joined so closely that much less mortar is required, the wall will be consequently more stable, and rats cannot burrow through it.

The color of the stone is light buff, the effect of which upon the eye is very pleasing in any building. Messrs. Parsons and Webb, and Krause, Shaw, Weaver, and Co. have erected kilns for the manufacture of lime from the same stone, using the refuse from the quarries for that purpose. The quality of the lime thus obtained, so far as examined, which was in mortar of a few years age, seems to be excellent.

Although the area within which this peculiar stratification occurs, is limited, as before stated, the supplies of excellent stone which may be obtained here is practically unlimited.

4. LE CLAIRE QUARRIES.

The town of Le Claire is situated upon the bank of the Mississippi river, about fifteen miles above Davenport. Its quarries are opened within the village and its outskirts, all of them being only a few rods from the river bank. The strata, like those of the Anamosa quarries, are all of Upper Silurian age, and the stone, like that of those quarries, is also magnesian limestone. Its color is quite a uniform light yellowish buff. It breaks with some difficulty with a dull, lustreless fracture, showing no trace of crystalline texture, except occasionally a faint, minute glimmer, common to most magnesian limestones. Analyses of specimens of it are given by Prof. Emery, in his report upon another page. The principal quarries are now wrought by Messrs. Gamble and

Co., who furnish much stone for important structures in various parts of the surrounding country, and at long distances upon the river. The perpendicular face of the strata exposed by quarrying within the village, is about thirty feet, and the best stone is obtained from those layers that compose the lower fifteen feet. These last named layers vary from six to twenty inches in thickness each, and are regularly and uniformly bedded. They are distinctly separated from each other by a slight interposition of soft material which leaves the bedding surfaces quite uniform and smooth, but not with that remarkable smoothness possessed by the layers at Anamosa. The stone is very uniform in texture for each layer; but although all valuable, some of them are superior to others for compactness and consequent value in important structures.

In the valley of a small creek, just upon the northern outskirts of the village, some of the layers are more massive, and blocks of two or three feet in thickness and of almost any desired size may be obtained. These Le Claire quarries have become quite noted for the building material that has been obtained from them, and they are yet capable of furnishing almost any quantity for which there may be a demand. The upper strata at and near this village, as well as the same strata at Port Byron, on the opposite side of the river, furnish abundant material for lime that has become justly famous for its excellence. This stone, as well as that of all the other strata, is magnesian limestone.

5. LE GRAND QUARRIES.

These quarries are located upon the right bank of the Iowa river, near the village of Le Grand, four miles east of Marshalltown, the quarries themselves being near the east boundary of Marshall county. The strata belong to the Kinderhook division of the Sub-carboniferous group, and consist, at that point, of light, yellowish bluff or light brown limestone, which is more or less magnesian in its composition. The whole thickness of the exposure here is about forty feet,

the layers varying from a few inches to three feet in thickness, the more massive ones being at and near the bottom. These lower layers are also more uniform in texture and more free from flinty masses and other impurities common in limestone than the upper layers are. Indeed, some ten or fifteen feet in thickness of these lower layers are so free from flinty nodules and specks, except occasional ones upon their bedding surfaces, that they are readily sawed into all desired shapes by means of the ordinary marble-saws propelled by machinery.

The upper layers are suitable only for the purposes to which ordinary stone is applied, but the lower layers furnish large quantities of good, massive building stone and blocks suitable for caps, sills, stone fronts, etc. Some portions of these massive layers are so beautifully veined by oxyd of iron that they furnish considerable quantities of stone suitable for ornamental purposes, which has become known under the name of "Iowa marble." The proprietors of the quarries, Messrs. Howe & Kirby, have erected machinery by means of which the common portions of these massive layers are sawed into desired shapes instead of being broken and dressed by the chisel in the ordinary manner. The veined portions are sawed by the same machinery into pieces of the desired shape for ornamental purposes.

It is proper to say here, that this stone is not, properly speaking, a marble, being softer and not crystalline, and, although it is a very valuable and beautiful stone for ornamental purposes for inside use, such as mantels, table-tops, etc., it cannot be recommended for use in monuments and other objects that are to be continuously exposed to the weather. It is believed that any polish that could be put upon it would become dull and disappear upon exposure to the weather during one or two years, while within doors, it would retain its polish indefinitely.

As a building stone, it is unobjectionable, because the minuteness of disintegration that would destroy a polish within a comparatively short time would not perceptibly

impair the durability of the stone in the walls of a building. These quarries are situated upon the line of the Chicago and Northwestern Railway, and are capable of furnishing very large quantities of material, and are among the very best quarries in the State, even for their ordinary stone.

6. KEOKUK QUARRIES.

The stone of these quarries belongs to the formation known as the Keokuk limestone, a member of the Sub-carboniferous group. Although those that have been opened in and around the city of Keokuk have furnished, and are now furnishing, large quantities of excellent stone, that having the requisite qualities for massive buildings which the formation has hitherto afforded, has been taken from the same strata where they are exposed near Nauvoo, twelve miles above Keokuk, on the opposite side of the Mississippi river. The same strata are also abundantly exposed on both sides of the river, along the whole distance between the two towns; and there seems to be no reason why we may not expect to find as good layers among them on the Iowa side of the Mississippi as upon the Illinois side. The stone from the Nauvoo quarries has been used in the construction of some important buildings among which is the Custom-House and Post Office building at Dubuque, whither it was carried in boats upon the river.

Whenever the erection of public and other important buildings may be contemplated, the exposures of the Keokuk limestone in the vicinity of that city are worthy of careful examination as a probable source of suitable material.

7. FARLEY QUARRIES.

These quarries are located about a mile north of Farley station, on the Dubuque and Sioux City Railroad, and are opened in strata of Upper Silurian age which are here, as everywhere else in Iowa, magnesian limestone. These strata, therefore, are of the same geological age as those of Leclaire

and Anamosa. The color of the stone is the usual light buff, with a tinge of yellow, so common to all the magnesian limestones of the State. In texture, it is firm and compact, breaking with a somewhat dull fracture. It is, like almost all the magnesian limestone of the State, non-crystalline, or at most showing only faint glimmering and very slight translucency at the thin edges of fractures.

The strata exposed in these quarries amounts to about twenty feet in vertical thickness, the layers each measuring from three or four inches to two feet in thickness. The layers are distinctly parted, but the texture of each is firm from the centre to the bedding surfaces. The best and thickest layers are as usual near the base of the quarry. Almost all the stone of the quarries is suitable for common use, but only a few of the layers are compact and massive enough for important structures, and these must be selected with some care to avoid the flinty nodules that sometimes occur imbedded in them.

Other quarries are opened at Epworth on the same railroad, four miles east from these, and are of about the same general character. Neither of these are so important as either the Anamosa or Le Claire quarries in the same formation, but they are referred to here as the practicable source from which stone may be obtained suitable for public buildings, particularly as they are located on an important line of railroad.

Other quarries of considerable importance are or may be opened upon lines of railroad from which very considerable but more limited supplies of stone may be obtained, such as is suitable for permanent and massive structures. Among these are the Kilbourne Station and Pella quarries, both of which are mentioned elsewhere in this report. The former are opened in the yellowish, buff-colored, magnesian layers of the St. Louis limestone formation (Sub-carboniferous), and the latter in the common gray limestone of the same formation. The quarries of both these localities are upon or near the line of the Des Moines Valley Railroad.

8. MARBLE.

No marble, properly so called, has been nor is any likely to be discovered in Iowa. The beautiful ornamental stone of the Le Grand quarries has just been described; but it is not marble although popularly included under that designation. Strictly speaking, marble is a fine quality of compact *crystalline* limestone, usually carbonate of lime with or without coloring matter. If the stone is crystalline in texture its hardness is necessarily such as receive a brilliant polish by rubbing alone, and to retain that polish permanently upon exposure to the atmosphere. None of our Iowa magnesian limestones are crystalline in texture except in a very slight degree, and are, consequently, too soft, wholly or in part, to receive and retain the requisite polish in exposed situations.

Several years ago much was popularly said of "Iowa City Marble," sometimes also called "Birds' Eye Marble." This is nothing more or less than fossil coral imbedded in the common Devonian limestone and often perfectly consolidated by carbonate of lime so that it may be polished like ordinary marble. When so polished its appearance is very beautiful, for the whole internal structure of the coral is as well shown as it is in living specimens, and yet it is hard and compact as real marble. This stone would be very valuable if it could be obtained in large pieces, but it occurs only in masses of a few pounds weight.

9. LIME.

Quicklime. Limestones, either magnesian or comparatively pure, form so large a part of the stratified rocks of Iowa that common lime may be prepared from them in all parts of the State where they are exposed. Theoretically, it would be naturally supposed that the nearer the stone approached to perfectly pure carbonate of lime the better would be the quicklime prepared from it. As far as the mechanical admixture of impurities is concerned, which the rock may have received in the course of its deposition, this is doubtless true; but magnesian limestones, that is, limestones formed by the

chemical union of carbonate of lime and carbonate of magnesia usually produce lime of superior quality for use in exposed masonry, better, in fact, than that obtained from the purest common limestone. The cause assigned for this by experts is, that when the latter is used for mortar in connection with sand, a silicate of lime is formed, and subsequently, carbonate of lime also by absorption of carbonic acid from the atmosphere, both these combinations serving as a cementing medium between the grains of sand. The same processes also take place when lime prepared from magnesian limestone is used for the same purpose, but in addition to those combinations a hydrate of magnesia is formed which adds a still further cementing property to the mass increasing its strength and durability.

Those parts of the State occupied by the Lower Silurian, Upper Silurian, Devonian, and in part by the Sub-carboniferous strata, as described in another part of this report, are abundantly supplied with magnesian limestone. Indeed, in some of those parts, the common limestone is absent entirely, but usually the former supply the most ample materials for lime well suited for every ordinary purpose. The Devonian strata are largely composed of quite pure limestone, besides its important beds of magnesian limestone. The Sub-carboniferous group is very largely composed of good common limestones, some important magnesian layers, occurring in its lower and upper formations. The Lower coal-measures contain almost no rock at all from which lime may be prepared. Within the limits occupied by this formation, however, the streams have not unfrequently cut their valleys down to the underlying Sub-carboniferous limestone, from which a good supply of lime is obtained even in that region. The Middle coal-measures also contain very little stone from which lime may be profitably prepared. The Upper coal-measures, which occupy the whole of Southwestern Iowa, contain limestone from which the best quality of lime, and in the greatest abundance may be obtained.

The whole northwest quarter of the State is so deeply covered by the Drift Deposit that only upon the borders of this great region, are exposures of strata of any kind to be found. This region, although it contains an abundance of lime in its soil, in a state of fine subdivision, derived doubtless from the destruction of Cretaceous and feldspathic rocks during the Drift epoch, is scantily supplied with materials for the production of quicklime. The only supplies to be obtained there are afforded by the chalky strata of Cretaceous age, found in the valley of the Big Sioux, in Plymouth and Woodbury counties, on its western border, and by the unfrequent exposures of the Sub-carboniferous limestone upon its eastern border. Very small quantities of an impure article of lime has been prepared from calcareous tufa which sometimes collects in considerable quantity where springs issue along the base of the bluffs in the counties bordering the Missouri river; but the supply of this material is very limited, and the product poor.

It will thus be seen that the whole State, except its north-western portion, is well supplied with materials for common lime, more particular reference to which is made in the detailed descriptions of the different parts of the State in this report.

10. HYDRAULIC LIME.

If hydraulic limestone consisted of any definite chemical compound as pure common and magnesian limestones do, and as many persons suppose the former does also, it would only require a simple analyses to determine the character and value of any deposit of it before actual trial as well as it could be known afterward. This is unfortunately not the case, and every individual deposit of a rock supposed to possess such properties, must be practically tested before one would be justified in erecting expensive works for its manufacture. Even if it is known to be chemically identical with other stone from which good hydraulic lime is successfully produced, it is safer to make the practical test in every

case. Analysis, indeed, should never be neglected, for by it we are often able to know that the stone analyzed cannot by any possibility produce hydraulic lime, and it may often go much farther and show that being in composition closely like some other limestone that has been successfully used for the production of hydraulic lime, this also may be reasonably expected to furnish similar results by similar treatment. Thus, although analyses are always valuable, it will be seen that the art of producing hydraulic lime, as well as the least method of using it after it is produced, is yet largely experimental.

The greatest proportion of every hydraulic limestone is carbonate of lime (pure limestone), and this substance may therefore be called the basis of all hydraulic limestone, because no rock has been known to produce a similar substance without its presence in the composition of the rock in very great proportion. When the hydraulic property of certain limes was first discovered it was supposed to be always due to the presence in the limestone from which it was prepared of from twenty to thirty per cent of clay, because the limestones first used for that purpose possessed such an admixture, while a less proportion failed to produce the full desired properties. It was afterwards found that magnesian limestones which contained only three or four per cent of clay, (instead of the twenty or thirty per cent required in the case of common limestones), also produced an equally good article of hydraulic lime. It will thus be seen that two different deposits of rock, differing widely in both chemical and physical characters, may each produce hydraulic lime of equal value and both excellent. Let us apply these facts to an examination of our Iowa limestones.

A lime possessing hydraulic properties, to some degree, was, several years ago, manufactured from the stone of a four-foot bed of bluish, impure limestone, belonging to the Lower coal-measures and exposed in the valley-side of Soap creek, in Davis county. This lime was used as a hydraulic lime in the construction of some of the dams of the Des

Moines River Improvement, then in course of construction. The stone was analyzed by Dr. Owen, and found to contain less of both alumina and magnesia than has hitherto been found requisite for the successful production of good hydraulic lime. No full history of its use has been obtained, and the most that can be said of it at present, is that it seems to have made a very good and durable mortar.

Some of the thin clayey limestone layers of both the Upper and Lower coal-measures may, perhaps, be found to possess hydraulic properties to some extent occasioned by the presence in them of silicate of alumina; but it is evident that these deposits are too slight to prove of any value even if their quality were excellent. All the other limestones of the State are so free from any considerable admixture of alumina that they probably derive no hydraulic properties from that mineral alone. We must, therefore, look to the magnesian limestones for material from which to obtain hydraulic lime, and we shall, doubtless, save labor and expense by directing investigation and experiment to these alone. Good, hydraulic lime evidently cannot be obtained from every magnesian limestone, and we must consequently determine which of those so abundant in some parts of Iowa are valuable for such purposes by actual experiment.

Within the first month after the present organization of the Survey, attention was called through the public press to certain magnesian limestone exposures in Black Hawk and Bremen counties as probably possessing hydraulic properties. The pressure of labor was so great that experiments could not be undertaken by any member of the Survey, but Mr. Robert D. Brown, a citizen of Waverly, Bremer county, commenced a series of experiments within the same year, the results of which are very gratifying. Commencing by burning limited quantities of the rock in an ordinary lime-kiln and grinding it by hand, Mr. Brown produced an article of lime that proved, upon trial, to possess hydraulic properties in an eminent degree. He has since constructed a kiln expressly for burning it, and together with a business partner is preparing to supply the market with hydraulic lime.

The rock is a buff-colored magnesian limestone, slightly gritty, but fine grained, and the greater part of it is so soft, when first taken from the quarry, that it may be crushed with a wooden mallet. Prof. Emery gives the results of his analysis of the rock upon another page of this report, but for convenience of reference, they are repeated here, as follows :

Water, (rock fresh from the quarry) .....	.75
Insoluble, (mostly silica).....	6.73
Alumina and per-oxyd of iron	5.45
Carbonate of lime	46.07
Carbonate of magnesia.....	40.90

The proportion of carbonate of magnesia in this stone is a little greater than it will average in the magnesian limestones of Iowa, if we exclude the other substances in this case besides carbonate of lime. It is probable that its hydraulic properties reside in both the silicate of alumina and the carbonate of magnesia, the presence of both in something near those proportions, being necessary.

When burnt and ground the lime has nearly a cream color. Being soft it is ground with the greatest facility to that degree of fineness so necessary to the perfect adhesion of the cement made from it. Although it contains so great proportion of common lime in its composition, it does not slake in water like that lime, even when fully burned. Sometimes lumps of it will grow perceptibly warmer when water is applied to it, but even then it does not crumble to pieces. After various experimental tests, Mr. Brown believes that four parts of sand to one part of lime are the best proportions for mixing the cement. In November and December of 1868, he constructed two cisterns in Waverly, using his own cement.

These were visited in the June following, and although they had been unnecessarily exposed to the frosts during the winter, they were then found perfect, the cement being hard and secure. The owners of the cisterns also expressed entire satisfaction with them. After such tests, and a knowledge

of the fact that in chemical composition, the rock is closely like some of the best hydraulic limestones of the East, there seems to be no reason to doubt that the Waverly hydraulic lime is fully equal, if not superior, to the Louisville hydraulic lime now generally found in our markets.

So far as known, these trials of Mr. Brown's are the only ones yet made in the State that have proved successful, if we may except that of Davis county, before mentioned. There is no reason to doubt, however, that some others of the numerous and abundant exposures of magnesian limestone in other parts of the State will furnish material for hydraulic lime.

11. SAND.

Although the Drift Deposit of Iowa contains in the aggregate a large amount of sand, derived originally from the sandstones which underlie it within the State, and the adjacent parts of Minnesota; and also from the quartz grains of the decomposed and glacier-ground granitic rocks of the latter State, yet it is mixed so thoroughly with the other and finer materials of the drift, that it is not often accessible in a condition pure enough for use in the arts, upon the undisturbed surface of that deposit. Thus upon the prairie and other upland surfaces there are no accumulations of it from which supplies for such purposes might be obtained, or the presence of which might impair the fertility of the soil. But wherever the streams have cut their valleys out of the drift, as nearly all of them have done, the finer portions having been carried away as sediment in the water, the sand being heavier, remains and is collected in irregular deposits along the shallows, shores, and flood-plains of the streams. These fluvatile accumulations furnish nearly all the sand used in the State, and the streams being numerous it is well supplied, the material being of sufficient purity for all ordinary purposes for which it is required.

There are, however, some portions of the State in which an abundant supply of sand is not to be obtained. This

is especially the case in the region occupied by the Bluff Deposit, before described, and which sometimes covers the drift to a depth of two hundred feet. This Bluff Deposit, although quite silicious in itself is nevertheless not sandy, for the silicious matter it contains, is in a too finely comminuted condition to be separated even as fine sand by the washings of the streams which traverse the region occupied by it. Consequently, the banks and flood-plains of these streams are never sandy, unless they have reached through the Bluff Deposit to the drift, and washed the latter in some portion of their course. The region occupied by the Bluff Deposit is principally comprised within those counties which border upon the Missouri river, and since the western part of all of them is occupied by the broad flood-plain of that river which, although very fertile, possesses some sandy places from which all necessary supplies of sand may be obtained, these counties too are very well supplied with sand. The larger tributaries, which meet the Missouri after traversing the counties just named, have cut their valleys entirely through the Bluff Deposit in some part of their course, so that even in this region it is not often necessary for the inhabitants to bring their sand from very long distances. This is a fortunate distribution of an indispensable material, both from its convenience of access and the fact that upon the general surface there are no accumulations of it worth mentioning that might impair the fertility of the soil.

12. CLAY.

The clays of the State may be divided into the impure drift clays and those more or less pure, the latter being found occupying their original place of deposit among the strata, but softened and modified by exposure to the atmosphere and frost. The drift clays are always mechanically mixed with other materials as would be expected from the circumstances of their origin. The same circumstances have also insured their general distribution throughout the State. These clays evidently had their origin in the clayey strata

which now underlie the drift of our own State and of Minnesota, and in the feldspathic rocks of the latter State, having been comminuted and moved to their present positions by glacial action. Thus, no considerable portion of Iowa is destitute of materials for the manufacture of good brick, although some parts are more plentifully supplied than others. Almost all our brick are made from the drift clays which are usually obtained upon or very near the surface. They vary very much in character and value according to the proportional amount of real clay they contain, their different degrees of fusibility, &c., but the failures that so frequently occur in their manufacture are due in a great degree to want of skill in the various processes of their manufacture, from the preparation of the clay to the final burning. In view of this fact, it is thought proper in a report like this to offer the following remarks upon the subject, but without any intention of presenting a treatise upon brick-making.

It is almost never the case that the clay of any one spot contains the proper proportions of ingredients to insure the production of the best quality of brick, but the wanting ingredients may almost always be obtained near by. Consequently, proper mixing and tempering of the clay is essential. Pure clay (silicate of alumina) alone will not make good building brick; neither will the same substance when combined with a proper proportion of sand unless the two be still further combined with some other ingredient that will act as a flux when they become heated in the kiln.

The requisite qualities of good building brick are: 1. Sufficient hardness to support great weight and resist decomposition. 2. Uniformity of size in the bricks when burnt, which is necessary for beauty in the structure and to insure uniformity in the settling of the wall. This is attained by the use of an ingredient, such as sand, which will prevent shrinkage while the bricks are burning and leave them in a condition of texture when burnt that will admit of their being cut with a trowel. 3. Fusibility, to insure the agglutination of the

particles that compose the mass, so that they have a firm and permanent cohesion. 4. Color.

Clay (*silicate of alumina*) supplies the first of these requisites, and furnishes what may be styled the "body" of the brick, and gives the mass plasticity in working. Sand or loam prevents the shrinkage of the mass while burning, without which the brick would be spoiled by making them irregular in size, too dense to be cut, and misshapen by "melting." Lime, magnesia, and the metallic oxides act as fluxes, giving the other materials sufficient fusibility to cause the particles of the whole to cohere firmly together. All three of these and especially lime are always present in our drift clays. The red color of brick is caused by the presence of per oxide of iron.

Much of our drift clay contains so great a proportion of real clay that they are unsuited alone to the production of good brick, and are commonly called "strong clays," or "stiff clays." These usually contain sufficient lime to cause them to flux easily if used without any admixture, and to "melt" in the kiln; besides which they crack so much in drying previous to being burnt that they will not bear handling. Such clay usually needs only an admixture of sand or loam to make excellent brick.

Although a certain proportion of real clay may be regarded as absolutely indispensable in a mixed material from which brick may be made, yet some very acceptable brick are made from material that really contains little more than a trace of clay. This is the case with the material known as the Bluff Deposit, described in another part of this report. In composition it contains nearly ninety per cent of finely comminuted, pure silex, and the greater part of the remainder is carbonate of lime. When obtained from near the base of the deposit, where it has received a very slight addition from the drift clay, an acceptable quality of brick has been made from it, the silicious matter which so greatly preponderates being slightly fluxed in the burning by the

lime it contains. Such brick, however, are apt to lack sufficient solidity for important and massive structures.

From the foregoing remarks it will be seen how absolutely essential it is that brick clays should be properly mixed, and especially properly tempered. All such clays ought, in fact, to be exposed at least one winter to the action of the frost. It will be readily inferred also that almost none of our Iowa brick clays have yet had a thorough test of their real merits.

Another source of imperfection in our bricks ought to be noticed. This is the presence in the clay of small fragments of limestone. The heat of the kiln changes these to quicklime, and when the brick is exposed to the weather, the water it absorbs reaches the lime, slakes it and causes the brick to burst. This is especially liable to occur in the brick manufactured from the bluff material, the limy concretions it contains acting in the same manner as the fragments of limestone.

The fact that all our brick materials are thus mechanically mixed in the drift, renders the process of brick-making almost entirely experimental, and makes complete success in that direction dependent upon practical experience with each kind of material.

During the present summer a box of clay, together with some specimens of brick made from the same, were forwarded to the office of the Survey by Mr. Dibble, of Clermont, in Clayton county. Time has not permitted a visit to that locality, as was intended, and it has only been learned that the clay is to be obtained in any desired quantity at the village of Clermont. It is evidently not a drift clay, but is probably obtained where it has weathered out from one of the clayey beds of the Trenton group. It is of a light, yellowish gray color, and the brick, when burned, retain nearly the same hue; being similar in that respect to the well known "Milwaukee brick," and their quality also is equally good. Prof. Emery gives an analysis of the clay in his chapter in another part of this report, among the results of which is the interesting fact that the iron it contains is in

the form of a carbonate, and not a peroxide, as in the case of the drift clays. The bricks of the latter, as is well known, receive their red color from the peroxide of iron. In the case of the Clermont clay the carbonic acid being expelled in the process of burning, the iron would be left in the form of a protoxide. Hence, probably, the unchanged color of the brick, which remains like the clay, of a light, yellowish, buff hue. Judging from the few samples of these bricks that have been examined, they are much superior to any yet seen in the State; and it is to be hoped that an abundant supply of clay exists there, as well as similar deposits in other parts.

Fire Clay or Refractory Clay. The clays to which these names are given, are compounds of silica and alumina in chemical combination, or the same with the addition of silica in excess. Such clays, when nearly free from admixture with any material that will act as a flux in the process of burning, or upon subsequent exposure to great heat, produce bricks that are very refractory in the presence of even the intense heat of a furnace. They are, for that reason, called fire-brick, and the clay from which they are made is called fire-clay. From the fact that in other coal-fields, some of the clay beds which almost everywhere underlie beds of coal were found to be true fire-clay, and all clays occupying similar positions have come to be very generally designated by that name, even when it is known that they do not possess refractory properties. This term is sometimes used in this report to designate the bed of clay that almost invariably appears immediately beneath each bed of coal. The coal-measure clays of Iowa, as well as most other clays yet seen within the State, contain so much lime and other fluxes that they are entirely unsuited to the production of fire-brick.

Potters' Clay. Our coal-measure clays are, however, the best and almost the only important pottery clays in the State. In some places they are purer and better than in others, and quite a number of important potteries are established in different parts of the State. Among these are the

potteries of Eldora, in Hardin county, the clay of which is also furnished to other potteries on the line of the Dubuque and Sioux City Railroad; of Fairport, in Muscatine county; of Des Moines; of Vernon, in Van Buren county; of Danville, in Des Moines county, and of Boonsboro, in Boone county. Some of the clayey beds of the Cretaceous strata of Woodbury county have been successfully used for pottery, but those of the Coal-measures will always furnish the best and most abundant materials for that purpose.

13. SLATE.

No true slate has been, or is likely to be found in Iowa. The substance popularly called slate, is black, carbonaceous shale, which, in some cases, readily splits into thin sheets, closely resembling roofing slate. It is found in various parts of the State, occupied by the Coal-measure formations, and occurs in beds of a foot or two in thickness among the other strata. It receives its dark color from the carbonaceous matter it contains, and which is often in so great proportion that the substance when perfectly dry, is quite combustible, but leaves an abundant shaly ash. It warps, splits, and decomposes when exposed to the weather for any considerable time, and is altogether quite worthless. It is sometimes worse than worthless, for in boring for coal these beds have been mistaken for coal-beds, on account of their color in the borings.

14. MATERIALS FOR PAINTS.

The only materials for paints yet discovered in Iowa, except such as are manufactured from lead, are ochery clays, and these have been tested only to a limited extent. They generally resemble closely in appearance and chemical composition, the cheap paint known in the markets under the name of "pecora." The only practical tests yet made of any of these ochery clays so far as yet known, has been done by Mr. J. B. Packard, of Red Oak, Montgomery county. He has used for that purpose the brownish, red clay mentioned

in the description of that county, grinding it finely in a small mill, and mixing it with linseed oil in the usual manner. The color of the paint when mixed is like the clay, a rather dark, brownish red, but it may of course be made lighter by the admixture of white lead.

Similar accumulations of colored, clayey material occur at Eldora, Fort Dodge, and various other places, especially among the Coal-measure strata.

15. ROAD MATERIALS.

The whole State is so deeply and completely covered, except in a part of its valleys, by its soft, incoherent surface deposits, and its exposures of rocky strata so limited, compared with the whole extent of surface, that its common roads must necessarily be constructed upon and out of the same soft materials, except a few in the immediate vicinity of the more important exposures of rock. Thus far, with few exceptions, all our public wagon roads are either upon the undisturbed surface of the soil, or constructed upon or out of such materials as the soil and subsoil in the immediate vicinity afford. The exceptions consist almost entirely of the paved streets of the cities and a few now abandoned plank roads.

Good deposits of gravel, except to a limited extent in Northern Iowa, are as rare as exposures of quarry rock are. There are considerable regions however, in Eastern Iowa, within which stone is sufficiently plentiful to afford material enough for the McAdamizing of its roads. This is especially the case in the valleys and in the vicinity of the following streams, namely: Upper Iowa, Turkey, Maquoketa, Wapsipinicon, Cedar, Iowa, (in part), Skunk, (lower portion), Des Moines, (lower portion), and Middle river.

In the middle and northern portions of Western Iowa, there is almost absolutely nothing for road materials, and little more in the greater part of Southwestern Iowa. In these parts "dirt roads" must always prevail. Such roads are, fortunately, quite unobjectionable, except in the spring

and autumn. It is fortunate, also, that in those parts where road materials are so completely wanting, the soil is less clayey and tenaceous.

16. WATER.

It could hardly be possible for a region to be more bountifully watered than the State of Iowa is, and yet so well drained that almost its entire surface not actually occupied by the streams, is available for agricultural purposes. The drainage systems of the State are such that the streams are numerous and uniformly distributed; valuable springs are frequent in the valleys, and even upon the highest prairies no difficulty is experienced in obtaining excellent water at only a few feet beneath the surface. In digging ordinary wells water is almost always found in the Drift Deposit, before reaching its base. Indeed wells that reach "the solid rock" are rare in Iowa. Usually, upon the prairies and other high general surfaces a sufficient supply of good wholesome water is obtained at a depth of from fifteen to thirty feet.

All the water of Iowa is what is popularly known as hard water; that is, it always holds more or less carbonate of lime in solution. It is, nevertheless, pure, limpid, and wholesome, the greatest objection to its use being the difficulty experienced in using it for washing purposes. For the latter purpose, rain water, collected in cisterns is generally used. The lime contained in the water that issues from, and in the vicinity of limestone strata, is easily accounted for; but its abundant presence in the well and spring water of the Drift and Bluff Deposits, which are now entirely unconnected with any limestone strata, is not quite so apparent without a knowledge of the origin and consequent composition of those deposits. It has been shown in another part of this report that the calcareous portion of the Bluff Deposit was derived from the chalky and other calcareous strata of the Cretaceous rocks. It has also been shown that there is good reason for believing that those strata once occupied the whole of the northwest quarter of Iowa and the adjacent portion of

Minnesota. These facts will of themselves account for the abundance of lime, in a finely comminuted condition, thoroughly intermixed with all those surface deposits of western Iowa; and the existence of the numerous limestone formations in the eastern half of the State and southwestern Minnesota together with the small proportion of lime known to exist in all the granitic rocks of that State, will just as fully account for the lime in the drift of eastern Iowa. It being thus known that lime is so thoroughly incorporated with the surface deposits of Iowa, no further examination is necessary to account for the origin of it in its waters.

17. ARTESIAN WELLS.

A number of artesian wells have been bored in different parts of the State, with more or less successful results; successful in having obtained water, but in nearly all cases the results were unsatisfactory to those who prosecuted the work because the kind of water or the substance sought for was not obtained. Some of these borings were made with the hope of obtaining petroleum, all of which were, of course, failures in that respect. Others were undertaken with the view of obtaining a large supply of pure water. Among the latter are those of the State Hospital for the Insane, at Mount Pleasant, and of breweries at Keokuk and Des Moines; and among the former are those of Keosauqua, in Van Buren county; of Harper's Ferry, in Allamakee county, and another seven miles below Davenport. Professor Emery has given analyses of a part of these, together with other waters, in his report. Some of them may probably prove to possess valuable medicinal properties to be used in the form of baths, &c.

The Mt. Pleasant well was bored for the purpose of obtaining a supply of pure water for the hospital, but it was found to be too impure, and to corrode the pipes and boilers so much that the use of the water was discontinued. Its depth was eleven hundred and twenty-five feet, the water rising to within thirty feet of the surface and remaining stationary

there. The temperature of the water was found to be quite uniform at 62° F.

The boring of the well at Farmington is reported to have been undertaken with the hope of finding petroleum, being commenced, like that at Mt. Pleasant, upon the St. Louis (Sub-carboniferous) limestone. Its depth is seven hundred and five feet from the surface, and the water flows out with considerable force.

The Keokuk well was bored by Mr. Joseph Kurz to obtain water for his brewery. He failed to get suitable water for that purpose, and has erected public baths in which to use the water. Its depth from the surface is about six hundred feet, being commenced upon the Keokuk limestone. The flow of water from this well is abundant.

The well at Des Moines was also bored to obtain water for a brewery, but little or nothing could be learned concerning it from the proprietors. It was commenced upon coal-measure strata, and the flow of water is quite plentiful.

The well seven miles below Davenport was commenced upon Devonian strata, and the object of the proprietors is said to have been "to obtain coal and oil." The water flows freely out upon the surface, and its depth is stated at eight hundred and three feet.

The well at Harper's Ferry, in Allamakee county, is also reported to have been bored with the hope of finding petroleum. The locality was not visited for want of time, and the water was sent for analysis by Dr. W. W. Ranney, of Lansing. It is quite remarkable that Prof. Emery, after the most careful tests failed to find any iron in it. This water has been reported to be strongly impregnated with salt. The analysis upon another page will show no warrant for such statements. The depth of this well has been variously stated, and it is proper to say here that it has always been found impossible to get a perfectly satisfactory account of the strata passed through by the drill in this or any similar borings. This is partly due to the great difficulty of ascertaining their actual character by an inspection of the

material brought up, and partly to the carelessness in that respect of those who are operating the drill.

The borings at the locality near Davenport, at Mt. Pleasant, Farmington, and Keokuk have all reached a greater or less depth beneath the level of the sea, but it need not thereby be supposed that their waters are derived from that source. A glance at the map-model of the State in volume one, will show the general dip of all the strata in the State to be to the southward, and slightly to the westward, except the Cretaceous strata of Western and Northwestern Iowa. From this fact it may be properly inferred that artesian borings in the eastern half of the State are likely to be more or less successful, so far as obtaining a flow of water is concerned.

By referring again to the map-model and to the chapter on General Geology, it will be seen that nearly all of the strata of the State are limestones, shales, clays, etc., such as might be expected to contain much matter that is more or less soluble, and that would impregnate the water of such artesian wells as might be bored in them. The pure sandstones probably contain less soluble matter than any others, and the water obtained in such formations would doubtless be much purer than that obtained from any of the other kind of strata just named. Therefore, it may be reasonably expected that artesian borings which should penetrate the St. Peters or Potsdam sandstone formations would yield purer water than those made in any of the other formations of Iowa. Both of those formations belong to the lower part of the Lower Silurian system, and the map-model will show their relation to the other formations of the State. It will be seen that while those sandstones may be reached at the least depth in Northeastern Iowa, it is reasonable to expect to reach the same in other parts of the State at a gradually increasing depth to the southward and westward.

18. MINERAL SPRINGS.

No mineral springs, properly so called, have yet been

known in Iowa, but it is not improbable that some of the water of the artesian wells just named will be found to contain mineral properties of medicinal value. See chemists report on waters.

19. "SALT SPRINGS."

Although no practically valuable accumulations of salt or of salt water have been found, in Iowa, the history of its "saline lands" has become a part of the State history. Its connection, also, real and supposed, with the geology of the State makes it proper to give the subject some attention here. The following condensed history of these lands has been kindly furnished by Hon. Geo. G. Wright, of the Supreme Bench :

"These lands were reserved from sale by the General Government when the sale of the public lands in Iowa was ordered, (see Brightly's Digest, 1789-1857, page 515, §334), and the President authorized to lease them. (See same authority, page 488, § 172). All salt springs in Iowa, not exceeding twelve in number, together with six sections of land contiguous to each, were granted to the State for its use, to be selected and to be used for such purposes as the State legislature may direct. (Brightly's Digest, same volume, page 443, clause 4, § 5). Under this act, there was no power to lease or sell for a longer time than ten years, without consent of Congress. These lands were selected by order of the legislature, in the counties of Appanoose, Davis, Decatur, Lucas, Monroe, Van Buren, and Wayne. By act of Congress, May 27, 1852, these lands were all released to the State of Iowa in fee-simple. After several acts of the legislature providing for their selection, some nine in number, they were finally granted to the State University, by act of April 2d, 1860. (Revision, §§1956-1957)."

Col. C. C. Carpenter, Register of the State Land Office, has also furnished this office with a full list of those lands amounting to 30,853.05 acres, but as the location of the greater part of them has no geological interest, a list of

those sections only is given upon which the reputed springs were located, giving the number of the section together with the number of the "spring."

Location of "Salt Springs"

SALT SPRING.	SECTION.	TOWNSHIP.	RANGE.	COUNTY.
No. 1.	20	68	10	Van Buren.
No. 2.	10	70	12	Davis.
No. 3.	1	70	17	Appanoose.
No. 4.	31	70	16	Appanoose.
No. 5.	28	69	24	Decatur.
No. 6.	10	72	21	Lucas.
No. 7.	21	72	21	Lucas.
No. 8.	1	71	21	Lucas.
No. 9.	10	71	22	Lucas.
No. 10.	1	70	22	Wayne.
No. 11.	9	71	21	Lucas.
No. 12.	13	71	21	Lucas.

All these localities have been visited by one or more members of the geological corps, and careful search made for the reputed salt springs, and in most cases we have failed to find any trace of them, and in the majority of cases no spring of any kind was found upon the section as indicated in the foregoing list. Diligent inquiry was also made of the early settlers of the region with no better success, one of whom quaintly remarked that he "supposed Iowa ought to have saline lands since Florida had them, which State was admitted into the Union at the same time with Iowa." We are, therefore, driven to the conclusion that *the persons who selected those lands as saline lands were in most cases mistaken as to their real character.*

It is a fact, however, that some of these springs as well as others in Iowa, do contain a sufficient amount of salt in their waters to be readily recognized by chemical tests. The principal of these are in Davis county, all of which were not reported as salt springs in that county by the Government Surveyors. Even those which contain the greatest amount of salt have so little that it is only barely perceptible to the

taste. Animals drink this water with avidity and resort to it from considerable distances, as deer were known to do before the settlement of the country; but many of the "deer licks" to which those animals were found resorting when the country was first settled, contrary to popular belief, contained no salt at all, at least no common salt. These "licks" exist in various parts of the State, particularly in those occupied by the pyritiferous shales of the coal-measures. They are springs or springy places, the waters of which contain, instead of salt, a small amount of sulphuretted hydrogen, and sometimes also, sulphate of iron. These impart a peculiar taste to the water, usually disagreeable to man, but animals, especially cattle, horses, and deer become exceedingly fond of it.

It may be remarked, that while nothing has been observed to encourage the hope of finding profitable accumulations of salt or salt water in Iowa, no positive reason is known why it should not occur here, and it is possible that by deepening some of these springs, brine may be obtained.

20. IRON.

Iron is one of the most universally distributed of all metals, and being, particularly in the form of oxides, one of the most conspicuous, it usually attracts more attention than any other metallic substance from those unacquainted with the general subject of metallurgy. Being disseminated throughout the drift as well as the stratified rocks, it is taken up in the water of some springs to such an extent that where it issues and stands in little pools upon the surface, the iron becomes precipitated in flocculent masses as sediment in the water, or occasionally covers it with an iridescent film, which, somewhat resembling the film that oil produces upon water, is sometimes popularly regarded as an indication of the existence of petroleum. Much oftener, however, among the people it is believed to indicate the existence of coal, and is then called "coal blossom" by them.

It is so abundantly disseminated throughout the drift in some places, probably in that form of the oxyd known as magnetite, as to effect the compass needles of the surveyors. As regards the appearances just mentioned it is proper to say that none of them are any indication whatever of the existence of either coal or petroleum, nor indeed are necessarily indications of any valuable deposits of iron ore. If the film in question is produced by petroleum, which is not likely to be the case in Iowa, it may be readily detected by its odor and other well known physical properties. Although such appearances of iron are almost universal within the limits of all coal-fields, yet they may and very often do exist under similar circumstances in situations where there is no coal, and where none has ever existed.

In the coal-measure shales and sandstones of Iowa frequent nodules and masses of sulphuret of iron, (iron pyrites) and also of hematite (oxyd of iron) are found, but always in small quantities, and practically valueless as ores; the former on account of the sulphur it contains, and the latter in consequence of the small quantities in which it occurs. In the sandstones of the coal-measures and also of the Cretaceous strata of Western Iowa, especially the latter, the oxyd of iron occurs in considerable abundance as a cementing ingredient of the sandstones. It frequently appears as veins in the sandstone, and sometimes in irregular masses, separated from the mass of the rock which is usually soft and friable. Although in some places, as for example in some parts of Guthrie county it is so abundant in this form as to excite considerable attention, it is hardly necessary to say that it is believed to be entirely worthless for any practical purpose. Small quantities of hematite have been found in Jones, Clayton, and Allamakee, as well as in several of the coal and other counties, some specimens of which are quite pure, but the amount is always small, and it should be borne in mind that large quantities of easily reducible ore, and of ready access, must be obtained, to be of any practical value. This is particularly true now that the

condition of commercial intercourse throughout the country is such as to enable manufacturers to carry the excellent ores from the Lake Superior iron region of Michigan and the Iron Mountain iron region of Missouri to other States, where proper fuel is abundant, and accessible, to be smelted in furnaces which were originally built for the purpose of smelting the ores from the ground they stand upon.

The ores from these remarkable localities can be obtained so cheaply and the supply is so constant and reliable that some iron mines elsewhere, which were formerly worked with profit, have become valueless in consequence. Thus, even if a deposit of iron ore should be discovered in Iowa, of sufficient extent to keep a furnace in operation, upon the completion of our projected system of north-and-south railroads, manufactured iron could probably be brought to us from the Missouri iron region for less money than it would cost to produce it here. The manufacture of iron from its own ores, therefore, can hardly be considered as among the porbable future industries of Iowa.

Sulphate of Iron (copperas) is always present in greater or less quantity in the shales associated with the coal-beds of the State among the interstices of the exposed portions of which it may sometimes be seen in the form of an efflorescence. It results from the decomposition by access of air and water from the surface, of the iron pyrites present in the shales. Where these shales, together with the refuse coal are thrown out in heaps around the mines, considerable quantities of copperas are incidentally produced in a natural way, but being soluble in water it is soon removed by the rains. The time perhaps will come when these shales will be utilized in the manufacture of that salt, but it is too cheap in the market and the supply of the crude material too precarious in Iowa to be of any practical value at present.

Sometimes this copperas (proto-sulphate of iron) changes by per-oxidation upon long exposure, and its solution appears in little pools about the mouths of coal-mines, in the form of a brownish-red colored water. Prof. Emery's

report contains an analysis of a sample of this from Monroe county.

21. LEAD.

The examination of the western half of the State having necessarily occupied so much time, it has been found impracticable to devote much attention to a full review of the eastern half. Consequently, we have not been able to add much to the able report of Prof. J. D. Whitney, upon the Dubuque Lead Region, contained in the former report upon the geology of Iowa. A short time, however, was devoted to the subject in the summer of 1867, with the following results.

A New York company has in course of construction an adit-level, such as was recommended by Prof. Whitney, for the purpose of draining a considerable area that experienced miners believe to contain large quantities of lead, now inaccessible on account of the constant presence of water there. It promises to be successful; and if so, a new era in Dubuque lead mining will thus be inaugurated, because there are several other areas within that region in the same condition. These may be as easily drained as the other and are believed to be equally rich in lead ore. With the exception of the commencement of this enterprise, little change has taken place in either mining or smelting during the past twenty years.

We hoped to have obtained statistical information as to the present and past product of the mines, but found it impracticable to obtain such as may be regarded as perfectly reliable. Indeed, the oldest and best informed mining and smelting proprietors were slow to express a definite opinion upon the subject for want of suitable data, although they were very willing to do so. From conversation with these gentlemen, I obtained the following impressions, namely: Lead mining is now in a moderately prosperous condition, but there were times in its history when more ore was raised per man than now. The increased price of lead, however, makes mining as profitable now as it ever was, but it requires

a somewhat greater proportion of labor and skill to obtain the ore now than it formerly did.

Up to the present time, there are no indications that deeper mining than is now practiced, will ever be profitable, nor indeed, in any degree productive in this region. Neither have any new general facts been obtained which seem to warrant any change of the opinions expressed by Prof. Whitney as to the depth or real extent of the lead deposit.

Capt. Thomas Levins, an old and experienced miner of Dubuque, called our attention to the well marked, physical difference between the ore of the east and west, and that of the north and south lodes, the ore being, in both cases, the sulphuret of lead. That of the east and west lodes, or crevices, is often found having the form of distinct cubical crystals, being often aggregated in large masses with their free faces presented outward from the centre of the mass or from the rock upon which they are attached. These lodes or crevices are wider than the others, and the ore, however abundant it may be, rarely or never fills them from side to side, so that the crystals have had free space to form in. The north and south lodes, on the contrary, are narrow, and the ore frequently fills them completely in the form of a distinct vein. Thus the crystalization has been confused and the fundamental cube is never seen in it. It is also of a slightly lighter color than that of the east and west lodes, in consequence of which it is called "steel mineral" by the miners. The opinion prevails, among the miners and smelters, that this "steel mineral" yields a greater percentage of lead than that which has crystalized in cubes. Probably some associated substances may produce this result, but there is no chemical difference between the two ores. It was suspected that if silver should be detected in any of the lead ore of the Dubuque region, it would be found in this north-and-south ore, but this is not the case, as will be seen from the results of Prof. Emery's analyses upon another page of this report. He also there gives the results of a series of analyses in search for silver, detecting only a trace in any of the ores or slags.

Mr. Simpson, of Rock Dale Smelting works, called our attention to a gray substance contained among the ore from a limited part of one of the mines, which greatly retarded the process of smelting (the Scotch hearth being used) and diminished the product of lead. The greater portion of it was amorphous, but some small crystals were detected amongst it. Analysis showed it to be carbonate of lead. This substance not unfrequently occurs as a thin incrustation upon the common ore where it has evidently been long exposed, but in this instance it was found interspersed in the small cavities between the crystals of the sulphuret. The carbonate alone, in sufficient quantity, is well known to be a good and profitable ore, but the objection to it in connection with the sulphuret seems to arise from the fact that it fuses at a lower degree of heat than the sulphuret, and flowing over the latter ore in the furnace it retards the combustion of the sulphur it contains, and the consequent liberation of the lead. This occurrence of the carbonate in that form seems quite exceptional and will probably not call for any change in the process of smelting, particularly as the "gray slag" from the Scotch hearth will yet contain the missing lead which will be saved by the usual second smelting in the blast furnace; and thus the whole customary product from the ore be secured.

22. ZINC.

Small quantities of zinc ores, both the carbonate and sulphuret are found in the lead mines of Dubuque, but thus far no practical use has been made of either of them in Iowa on account of the small quantities in which they occur. The sulphuret occurs in the usual crystalline and crystalized forms, and the carbonate, in the form of "dry bone" and crystalline layers alternating with similar layers of the sulphuret upon the face of the rock in the crevices.

Zinc is also found in the form of the sulphuret in minute quantities in several other formations of the State. It has been thus found in the rocks of Devonian age, in every member of the Sub-carboniferous group and in the Lower coal-

measures. In the latter formation it occurs in iron-clay nodules filling the septaria-like seams which traverse them. In this form it has been found in Wapello, Webster, and other counties.

The deposits of zinc in any form in Iowa are doubtless too limited to be of any value except as mineralogical facts.

23. SILVER.

To most persons it will doubtless seem superfluous to offer any remarks in relation to silver in Iowa, but during the present year (1868), considerable local excitement has been caused by the alleged discovery of silver in Cedar county. These reports were believed by many to be true, especially when pieces of silver, or a metallic compound resembling it, were shown as the product of the rock reported to contain it. This rock is of Devonian age, and consists of more or less irregular layers and concretions of carbonate of lime, occasionally having fine crystalline specks of iron pyrites disseminated through it. A number of specimens of this rock have been obtained both by personal selection and from persons interested in knowing the facts in the case. These have been carefully analyzed by Prof. Emery, the details of which will be found in his report upon another page. The result is that no trace of silver has been detected in any instance.

There is little probability that silver will be found as a mineral in Iowa, except as the merest trace in the lead ores of Dubuque, and as specks in the rare lumps of native copper, that may be found in the Drift.

24. COPPER.

It is not known that any trace of copper or any of its ores have been found in Iowa, and nothing has been observed which encourages the belief that any will ever be discovered. The only exception that may be made to this general statement is the small lumps of native copper found in the Drift, the origin of which has been fully explained in another part of this report.

CHEMIST'S REPORT.

TO DR. C. A. WHITE, *State Geologist of Iowa* :

SIR:—I have the honor herewith to present my report of the Chemical work of the State Geological Survey of Iowa.

I remain, sir, yours very respectfully,

RUSH EMERY, *Chemist.*

IOWA CITY, IOWA, Sept. 6th, 1869.

CHAPTER IV.

SECTION I.

1. ROCKS AND MINERALS.

In this section are given the results of the analyses and examinations of the rocks and minerals. In many of these it was only desired to have partial analyses made, or to have an examination made for the presence of some particular element. These examinations are grouped in tabular forms, as far as possible.

Hydraulic Limestone from Waverly, Bremer County. The rock is of a light gray color, most of it being quite homogeneous apparently; but in a few places, the rock appears to be penetrated by light bands of ferruginous matter. It is very soft when fresh from the quarry; but hardens upon exposure to the atmosphere.

A number of analyses gives the following as the average composition of the rock:

Insoluble.....	7.42
Alumina and Ferric Oxyd.....	3.20
Calcium Carbonate.....	49.32
Magnesium Carbonate.....	37.59
Water, traces, and loss.....	2.47
Total.....	100.00

The insoluble matter consists of a fine white sand. The precipitate of alumina and ferric oxyd consists mainly of the former.

It was also found that a sample taken from the interior of

a large piece of the rock, contained about five times the amount of water found in that part of the rock which had been exposed for some to the air. The rock is said to succeed admirably as a hydraulic limestone.

Magnesian Limestone from Anamosa, from the quarry of Parsons and Webb. This is a gray rock, breaking into irregular fragments, and seems to have no tendency to split into laminæ. It is very hard. The analyses gave:

Insoluble in acid .....	.72
Ferrous and Ferric Oxyds. ....	.23
Calcium carbonate.....	57.32
Magnesian carbonate	41.21
Moisture.....	.31
	<hr/> 99.79

The percentage of insoluble matter seems too small for a good hydraulic limestone, although the magnesium carbonate exists in large proportion.

Analyses of Sediment of Missouri river water. No. 1 is at low water stage; No. 2 at high:

	No. 1.	No. 2.
Insoluble.....	75.23	84.11
Iron and alumina	15.19	6.85
Calcium carbonate	7.51	5.45
Magnesium carbonate	1.49	2.52
Organic matter, traces and loss.....	.58	1.07
	<hr/> 100.00	<hr/> 100.00

For an examination of the waters at high and low stages, see Section II. The insoluble consisted of silicious, and some ferruginous and argillaceous matter.

Analyses of the Bluff Deposit. This deposit is of a light-yellowish color, and appears at first sight as though it contained little else than sand. A single analysis was made of a sample from near Sioux City, and of another from Council Bluffs, numbered respectively 1 and 5, with the following results:

	No. 1.	No. 2.
Insoluble (silicious matter)	82.15	83.55
Ferric oxyd.....	3.89	4.98
Alumina .....	.67	
Calcium carbonate	9.66	7.00
Magnesium carbonate	1.31	2.09
Moisture	1.09	1.11
Organic matter, traces and loss	1.23	1.27
	<u>100.00</u>	<u>100.00</u>

The insoluble matter consists mainly of silica. In the second analysis, the iron and alumina were not separated, the reactions showing that iron formed by far the larger part.

Rock from Gambele and Co's quarry, Le Claire.—The rock is gray, some of the samples having a yellowish tinge. It is of moderate hardness, and has a gritty feel, and somewhat of a finely crystalline structure. The analyses gave :

Insoluble	3.33
Alumina and Ferric oxyd .....	.74
Magnesian carbonate.....	41.70
Calcium carbonate (by difference).....	<u>54.23</u>
	100.00

A good building stone, and extensively used for that purpose.

"Iowa Marble," from the Le Grand quarries, Marshall county. This is a gray rock with a tinge of yellow. It is of moderate hardness, quite fine-grained,, and admits of a considerable polish. It does not appear to be entirely uniform in its structure, being somewhat marked by waving lines and rings. The results of the analysis are :

Insoluble ..	1.71
Moisture.....	.59
Ferric oxyd.....	1.08
Calcium carbonate.....	75.42
Magnesium carbonate.....	<u>20.96</u>
	99.76

It is an excellent building rock.

Ferruginous Limestone from the Sub-carboniferous, at Hardin City, Hardin county. The rock is of a red to purple color, of only moderate hardness, crushing easily. Its composition is :

Insoluble.....	.19
Moisture .....	.32
Ferric oxyd.....	10.03
Magnesium carbonate.....	15.97
Calcium carbonate (by difference)	73.49
	<hr/> 100.00

Traces of alumina and sulphuric acid were found.

Ferruginous Rocks. The following schedule presents the results of a few examinations of rocks, relative to their percentage of iron and insoluble matter :

No.	Percentage of iron, reduced to metallic iron.	Percentage of insoluble matter.	Character of Insoluble matter.
1.	4.06	82.67.....	A beautiful clean white sand.
2.	50.55	18.59.....	Consists partly of clean white sand and partly of light colored, argillaceous matter
3.	5.76	47.60.....	Fine argillaceous matter.
4.	47.76	31.22.....	Consists mainly of clean white sand.

No. 1 is from a gravel-bed in the bank of Mariner's creek, near Dennison, Crawford county, and is a black mass, appearing almost metallic, and having pebbles of some considerable size scattered through it. A little lime is present.

No. 2 is from the ferruginous bed immediately beneath, and associated with the gypsum, on Soldier creek, Fort Dodge. The sample is very hard, and has a color varying from red to purple. A little white substance is disseminated through it. Some lime present.

No. 3 is from Summerset, Warren county; is of a purple-red color, and seems to be an aggregation of rudely cubical masses. It contains a large quantity of lime.

No. 4 is from the ferruginous deposits at Guthrie Center,

Guthrie county, and is of a dark color, inclining to red. It contains only a trace of lime.

2. EXAMINATION OF LEAD ORES FOR PRESENCE OF SILVER.

The samples examined were all labeled from "Rock Dale Furnace, near Dubuque," and were carefully tested in the ordinary wet way, with the following results:

<i>Sample.</i>	<i>Result.</i>
Galena, "East-and-West"	Trace of silver present.
Galena, "North-and-South"	No trace detected.
Gray slag	Faint trace.
Black slag	No trace.
Soft lead	No trace.
Skimmings from soft lead....	No trace.
Slag lead	No trace.

The different products of the furnace were thus examined; since, in this manner, it was not impossible that a single sample might be a mixture of ores from many parts of the mine, and also, because in the various processes through which these products had passed in the furnace, a relatively large proportion of silver might have been separated, and thus its detection facilitated. The quantities of lead used in each of the above investigations, varied from 13 to 44 grams.

3. CLAYS

Sample from Dibble's brick-yard, Clermont, Fayette County. The bricks made from this clay are very hard, and of a cream color. The clay itself is of nearly the same color, with slight tinges of red, caused by the presence of ferric oxyd. Most of the iron, however, appears to be present as a protosalt; and from this fact, and the large amount of carbonic acid, it is probable that the iron is present as a carbonate. A single assay gives seven per cent. of iron, and thirty-nine per cent of insoluble clay. Calcium carbonate is present in large quantity.

White Clay from the banks of the Middle Coon river, near Carrollton, Carroll County. It is quite white; marks like chalk; cuts very easily. It is almost entirely composed of insoluble silicious and argillaceous matter; but three and seventy-eighth hundredths per cent. being dissolved upon long digestion with sulphuric acid.

Potters' Clay from Beds, Nos. 2 and 3, Sergeant's Bluffs, Woodbury County. Under the same treatment as the preceding, this clay gives an insoluble residue of 90.11 per cent., which is a little more silicious than that of the white clay. The color of this clay is dark gray.

4. SUNDRY QUALITATIVE ANALYSES.

The following rocks were tested for the presence of the substances indicated below:

No.	Tested for presence of.	Result of examination.
1.	Silver.	No trace.
2.	Phosphoric acid.	Present.
3.	Magnesium.	Present.
4.	Magnesium.	Absent.
5.	Phosphoric acid.	Present.
6.	Phosphoric acid.	Present.
7.	Magnesium.	Present.

No. 1 is a limestone from the Devonian, three miles north-east of Rochester, Cedar county.

No. 2 is from the fish-beds of the Burlington limestone, Sub-carboniferous; Louisa county.

No. 3 is a limestone from the calcareous layers of the Maquoketa shales, and contain *Orthoceras* in great numbers.

No. 4. is from the Middle Coal-measures, Greenbush, Warren county.

No. 5. is a coprolite (?) from the carbonaceous shales, Middle Coal-measures, Greenbush, Warren county.

No. 6 is a coprolite (?) from the carbonaceous shales, near Agency, Wapello county.

No. 7 is a limestone from the base of the Coal-measures, Hardin county.

The following rocks were examined with regard to their percentage of insoluble matter and the general character of the rock :

<i>No.</i>	<i>Percentage of Insoluble.</i>	<i>Character of Insoluble.</i>
1.	64.92...	Consists of miniature pebbles.
2.	5.90.....	Mainly argillaceous matter.
3.	3.97.....	Consist mostly of fine, white sand.
4.	12.21.....	Gray, silicious, and argillaceous matter.
5.	13.51.....	Dark colored, argillaceous matter.
6.	78.06.....	Clean, white sand.
7.	5.75.....	Fine-grained, gray, argillaceous matter.
8.	63.76.....	Very fine-grained, white sand.
9.	16.07.....	Argillaceous, and a little ferruginous matter.
10.	46.12.....	Rather coarse, white sand.
11.	7.69.....	Dark, fine, silicious, and argillaceous matter.
12.	22.96.....	Bluish, fine, silicious, and argillaceous matter.

No. 1 is a sample of "natural concrete, taken from the base of the bluff formation at Bruguière's Bluff, above Sioux City," and is of a gray color, and composed of miniature pebbles about the size of a mustard seed, held together by calcium carbonate.

No. 2 is a sample of chalk from the "Inoceramus Beds" of the Cretaceous, above Sioux City. It is nearly white, crushes like chalk; might be used for crayons; and its soluble portion is nearly pure calcium carbonate.

No. 3 is from the base of the Middle coal-measures, at Mosquito creek, Dallas county. It is a light gray rock; hard, crystalline, and full of fossils. It is a limestone.

No. 4 is from St. Onge's Bluff, Woodbury county, from the upper portion of Woodbury formation; Cretaceous. It is a limestone of soft structure, crushing about as easily as a crayon, but with a gritty feeling in the mortar. It makes a light mark when drawn across a surface of wood. It is fossiliferous.

No. 5 is from Blackburn's Monona county; taken from a depth of sixty feet below the surface—below the surface of the Missouri river. It is essentially a chalk; is of a light gray color, easily crushed, marks distinctly.

No. 6 is a sandstone, inclosed in ferruginous layers, immediately below the gypsum on Soldier's creek, Fort Dodge. It is of a reddish gray color, rather hard, but yet crushing without great difficulty, fine grained.

No. 7 is from Talbot's factory, bed No. 10, Appanoose county. It is a gray, hard limestone, containing but a very small quantity of magnesium, and is entirely unfit for hydraulic limestone.

No. 8 is a quarry rock from the base of the exposures at Sioux City. It is of a gray color, quite hard, and has a number of thin layers of carbonaceous matter running through it. The soluble part consists mainly of calcium carbonate.

No. 9 is a limestone with considerable ferruginous matter, from Mosquito creek, Dallas county. It is very hard, and is composed of small masses of various colors, as yellow, brown, gray, etc.

No. 10 is a highly silicious limestone from the Drift, Boyer valley, Dennison. It is gray rock, crystalline in structure, quite hard, and fossiliferous.

No. 11 is a limestone from Middle Coal-measures on South Raccoon, (bed No. 14, c, General Section of Middle Coal-measures). It occurs in thin layers; is of a dark color, very hard, and full of fossils. It contains considerable magnesium carbonate.

No. 12 is a limestone from same locality as the preceding, (bed No. 14, a, General Section of Middle Coal-measures). It is a gray rock, hard, fossiliferous, and contains considerable magnesium carbonate.

5. SULPHATES OF THE ALKALINE EARTHS.

Saltpetre. This mineral is found in minute quantity at Lansing, efflorescing upon the surface of a Potsdam sandstone cliff. It occurs in fine needleform crystals. It contains many foreign ingredients, distinct reactions being obtained for sulphuric acid, calcium and magnesium, and a faint

reaction for hydrochloric acid. An insoluble residue of clean, white sand also remained.

Shale from the Lower Cretaceous formation, on Big Sioux river, in Woodbury county. (See section at St. Onge's, bed No. 1, under head of Woodbury county).

The sample has a sour taste, due to the presence of ferrous sulphate in considerable quantity. A small amount of alumina is also present in the soluble part.

Epsomite. This mineral, in small quantity, is found near Burlington. It is somewhat mixed with foreign matter, consisting of clay, iron, chlorine, and sodium; the two latter being present only in very small quantities. A determination of a single specimen gave 91.19 per cent of magnesium sulphate. As the samples at hand were not homogeneous it is obvious that this result can be taken only as a mere approximation to the amount contained in the deposit.

Celestine. Of this mineral, two varieties occur in the vicinity of Fort Dodge. One of these is of a beautiful azure blue color, fibrous, and occurs in layers, three or four inches in thickness. The other variety occurs in clear white prisms, and is found in masses a foot or more in diameter, and composed of the crystals loosely aggregated. These masses occur in the clay above the gypsum deposits.

6. GYPSUM.

Of the varieties of this valuable mineral which are found in such abundance at Fort Dodge, the white and the fibrous appear to be chemically pure. A number of samples of these were examined, which gave no reactions showing the presence of foreign matter.

With the gray gypsum, however, the case is different. The impurities in this variety seem to be largely concentrated in thin bands of a dark color, between which are strata of a much higher degree of purity. But in neither case are the foreign ingredients present in quantities sufficient to seriously impair its value. The darkest varieties of the gray gypsum

when pulverized, form a white powder, with a scarcely visible tinge of gray.

The impurities consist of argillaceous matter, silicious matter, calcium carbonate, and iron. Two assays were made of this variety; the one, of the lighter colored portions; the other, of the dark bands. The results gave respectively 98.63 and 85.53 per cent. of gypsum.

SECTION II.

1. WATERS.

In this sections are comprised the results of the investigations made of the waters of the State. The examinations have been made as full and complete as was possible, taking into consideration the amount of time which could be devoted to them, the quantity and freshness of the water at disposal, etc.

Water from Kinersly's well, one mile from Keosauqua, Van Buren county. The water is very strongly acid. It contains per liter 1.12 grams of ferruginous sediment, and 8.18 grams of solid matter in solution, making a total of 9.3 grams of solid matter per liter. Its principal constituent is ferric sulphate. It also contains considerable gypsum, sodium, and hydrochloric acid. A portion of the sulphuric acid is free; the amount per liter contained in the water being 3.306 grams. The water also contains 1.58 grams of ferric oxyd, and 0.403 grams of Calcium oxyd per liter.

Water from a Peat Marsh in Cerro Gordo county. The water was collected just after heavy rains, and was taken from near the surface of the marsh. It contained a large quantity of finely divided peat, which was carefully separated. The clear water contained in one liter .323 grams of solid matter, of which there are .112 grams of calcium oxyd, .029 of magnesium oxyd, and .028 of chlorine. Carbonic acid was present in large quantity; as also sodium and iron. Sulphuric acid was present in small quantity.

Water from Maulsbye's Spring, Dallas county. The

amount of solid matter is 1.38 grams per liter; the principal constituents of which are calcium and magnesium sulphates. A small quantity of phosphoric acid was also present. No trace of iron.

Water from the Missouri river at Council Bluffs. Two samples of this water were examined, one collected July 5th, 1868, at high water; the other in November of the same year, at low water. From the first, the sediment was separated by filtration, amounting to 5.672 grams per liter of water; the sediment of the second was separated in like manner, and amounted to .462 grams per liter. For analyses of these sediments, see Section I. Only a qualitative examination was made of the waters.

The total solid matter held in solution amounts in the high water, to .157 grams per liter; in the low water, to .287 grams per liter. Lime, iron, sodium, and carbonic acid, and hydrochloric acid are present in large quantities; sulphuric acid, magnesium, and organic matter in smaller proportions. Potassium shows only a faint reaction. More iron seemed present in the high water. It will be noticed that the amount of sediment is much greater in the high water, while the reverse is the case with regard to the solid matter held in solution, although in a less marked degree. We might naturally expect this, since in time of high water, a mere mechanical force is principally exerted to tear the particles from the rocks, etc., against which the stream impinges; while at low water, the solvent power of this medium has had ample time to exert its full force upon the particles previously disengaged.

Water from the Artesian Well at Farmington, Van Buren county. One liter of this water gives 3.21 grams of solid matter, containing:

Sulphuric Acid.....	1.330 grams.
Hydrochloric Acid.....	.228 grams.
Iron and Insoluble.....	.021 grams.
Calcium Oxyd.....	.440 grams.
Magnesium Oxyd.....	.177 grams.

But little carbonic acid was present; much sodium.

Water from Fellow's Grove, Carroll county. This water contains in one liter, 3.06 grams of solid matter, of which the following determinations were made:

Sulphuric Acid.....	1.583 grams.
Ferric Oxyd....	.040 grams.
Calcium Oxyd.....	.423 grams.
Magnesium Oxyd.....	.243 grams.

Chlorine and sodium are present, the latter in considerable quantity.

Water from the Mouth of a Coal-mine on Bluff creek, Monroe county. The water is of a bright red color, and contains the enormous quantity of 116.9 grams of solid matter per liter. It is strongly acid, containing free sulphuric acid, and a small amount of phosphoric acid. The amount of sulphuric acid per liter is 43.4 grams, and of ferric oxyd 36.5 grams. No other determinations were made.

Spring Water from the base of the Gypsum Deposit at Fort Dodge. The water has an Alkaline reaction, and an unpleasant taste. Gypsum is the principal ingredient. The following determinations were made :

Solid matter in one liter	2.29 grams.
Sulphuric acid.....	1.056 grams.
Calcium oxyd .....	.451 grams.
Magnesium oxyd....	.07 grams.

Only a little carbonic acid was present. Sodium gave a distinct reaction ; hydrochloric acid a very faint one.

Water from the Artesian Well at Harper's Ferry, Allamakee county. (Sent by Dr. W. W. Ranney). One liter of the water contains .79 grams of solid matter, of which there are, of

Sulphuric acid .....	.082 grams.
Hydrochloric acid.....	.193 grams.
Calcium oxyd .....	.096 grams.
Magnesium oxyd .....	.045 grams.

Much sodium and carbonic acid present. No iron was detected.

Water from Artesian Well, seven miles below Davenport. The water is clear, and deposits a scarcely perceptible sediment after standing for some time. The water has a brackish taste and an alkaline reaction. The solid matter which it holds in solution consists mainly of salts of sodium. One liter of the water contains :

Calcium carbonate .....	.024 grams.
Magnesium carbonate.....	.021 grams.
Sodium chloride.....	.138 grams.
Sodium sulphate.....	.486 grams.
Sodium carbonate	291 grams.
Silica, alumina, traces and loss.....	.060 grams.
Total	1.020 grams.

The water contains a small quantity of salts of potassium. No trace of iron was found. An examination was also made of a mineral deposit, taken from the iron pipe through which the water flows. Its taste is sufficient to show that sodium chloride forms no small part of it. It also contains, in large quantity, sulphuric and carbonic acids. Much ferric oxyd was also present, doubtless a product of the decomposition of the iron pipe through which the water of the well flows.

SECTION III.

2. COALS.

In this section are comprised the results of the examinations of our coals. The so-called "proximate analysis" has been followed exclusively in these examinations. This method of analysis consists of: 1st, the expulsion of the *moisture* contained in the coal, at a temperature of 150°—110° C.; 2d, the expulsion of the *volatile combustible matter* at a high temperature, in a platinum crucible with an accurately fitted cover, the crucible being suddenly cooled upon the completion of the operation; 3d, the decarbonization of the *coke* formed by the second process above.

The loss in weight of the original coal

in the $\left\{ \begin{array}{l} \text{1st.} \\ \text{2d.} \\ \text{3d.} \end{array} \right\}$ process, gives the $\left\{ \begin{array}{l} \text{Moisture.} \\ \text{Volatile combustible matter.} \\ \text{Fixed carbon.} \end{array} \right\}$

The residue left after incineration, gives the amount of *ash* or mineral matter.

A majority of the following analyses are the means of two. Great care was taken to secure the entire completion of the several processes, and the slight deviations from the means of the two determinations, in cases where the samples were mixed previous to the analyses, show that this method gives results which will compare favorably, in some cases, with quantitative analyses of rocks, etc. The following are some of the deviations from the means of two determinations. In many cases, where the sample did not appear homogeneous in its structure, the samples for the two analyses were taken purposely from different parts of the coal, not mixed, and the mean of the analyses taken. These coals, of which only single analyses were made, were mainly from counties represented by a considerable number of specimens:

DEVIATIONS.

NO.	COUNTY.	MOISTURE.	VOLATILE COMB.	FIXED CARBON.	ASH.
5.	Mahaska	.08	.19	.46	.17
4.	Marion	.13	.37	.31	.07
1.	Jasper	.25	.67	.34	.08
4.	Monroe	.02	.02	.09	.08
5.	Monroe	.09	.15	.40	.46
2.	Guthrie	.21	.23	.11	.13
1.	Dallas	.16	.17	.03	.02
1.	Boone	.29	.00	.25	.55
1.	Greene	.07	.40	.64	.17
5.	Webster	.24	.005	.015	.22
3.	Webster	.14	.13	.03	.04
4.	Webster	.09	.37	.32	.14
1.	Poweshiek	.22	.34	.31	.43

In determining the ash, the sample was not picked clean of

all visible mineral matter. A sample representing a fair average of the coal, as nearly as possible, was taken and used entire. It is believed that this method will give a better idea of the quality of our coals, than would be possible where the sample taken for analysis is freed from any portion of its impurities, although it may not give as flattering an exhibit as would otherwise be made.

It only remains, before proceeding to the description of the samples, and the results of their analyses, to explain the significance of the figures given in these analyses. Take for example, the sample from the top of Hon. C. Dudley's mine, in Wapello county. In one hundred pounds of this coal, previous to drying,* there are about five and one-half pounds of *moisture*, forty-five and three-quarter pounds of *volatile combustible matter*, forty-six and three-quarter pounds of *fixed carbon*, and two pounds of *ash*. After all the moisture has been completely expelled from the coal, one hundred pounds of it contains forty-eight and one-half pounds of *volatile combustible matter*, forty-nine and one-half pounds of *fixed carbon*, and two pounds of *ash*. By adding together the five and one-half pounds of *moisture* and the forty-five and three-quarter pounds of *volatile combustible matter* of the undried coal, we obtain fifty-one and one-quarter pounds of volatile matter in it; or, as it is termed in the analyses, the *total volatile*. In like manner, forty-five and three-quarters added to forty-six and three-quarters, equals ninety-two and one-half pounds in one hundred pounds, or the number of pounds of combustible matter, called *total combustible* in the analyses. Also, forty-six and three-quarter pounds of fixed carbon added to two pounds of ash, equals forty-eight and three-quarter pounds of *coke* in one hundred pounds of undried coal. By processes, entirely analogous, we find the *total combustible* and *coke* in the dried coal. Also, one hundred pounds of the *coke*

*It is doubtless true that the percentage of water would be larger in coal taken fresh from the mine, and which had not been kept for some time in a heated room. See remarks at the end of this sub-section.

contain about ninety-six pounds of *carbon* and four pounds of *ash*.

With regard to the practical application of these analyses to the valuation of coals, it is perhaps sufficient to state:

1. The value of coal as fuel is inversely proportional to the amount of moisture contained in it; that is, the more water it contains the less is its value. And moisture is a damage to the coal, not only because it takes the place of what might otherwise be occupied by combustible matter, but also because it requires some of the heat generated by the burning of the combustible matter to transform it into steam, and thus to expel it. It will thus be seen that the presence of large quantities of moisture in coal, seriously impairs its value. But in looking over the analyses given, it should be remembered that some of the coals were taken fresh from the mine, others had been kept for some time in a damp room, while others had been subjected to the high temperature of a heated room for a considerable length of time.

2. The greater the percentage of ash, the less is the value of the coal.

3. The more fixed carbon which the coal contains, the greater is its value.

4. The same holds true with regard to the volatile combustible matter, *to a limited extent*, the precise limits of which cannot be determined until we know the composition of this combustible matter.

MONROE COUNTY.

No. 1. *From Miller's Mine, eight miles east of Albia. From the bottom of the mine.* The sample is irregular in fracture and stratification. It is somewhat scaly; breaks easily into fragments. Transverse to the imperfect strata, are a few seams of calcareous matter, and a little pyrite. Considerable mineral charcoal is present. Coal soils fingers much in handling. A part of one of surfaces of sample is covered with a layer of very clean, hard coal, black and

glossy, separated into small sections by thin seams of calcareous matter. Coke has a metallic lustre. Color of ash, gray, with a slight blue tinge.

No. 2. *From the top of same mine.* This sample is more compact, and more distinctly laminated than that from the bottom. Numerous thin bands of calcareous matter penetrate the mass transversely to the planes of lamination. Pyrite is also present. The coke is spongy with a bright metallic lustre. The ash is scarcely distinguishable from the preceding.

The thickness of the bank from which the above samples were taken is about four feet.

The result of the analyses are as follows:

	<i>Bottom, No. 1.</i>	<i>Top, No. 2.</i>
Moisture.....	4.71	4.57
Volatile combustible.....	37.84	43.80
Fixed carbon.....	51.30	45.22
Ash... ..	6.15	6.41
	<hr/> 100.00	<hr/> 100.00

Composition calculated on dried coal:

Volatile combustible.....	39.70	45.89
Fixed carbon.....	53.84	47.39
Ash.....	6.46	6.72
	<hr/> 100.00	<hr/> 100.00

	<i>No. 1.</i>	<i>No. 2.</i>
Total volatile.....	42.55	48.37 of undried coal.
Total combustible.....	{ 89.14	89.02 } of undried coal.
	{ 93.54	93.28 } of dried coal.
Coke.....	{ 57.45	51.63 } of undried coal.
	{ 60.30	54.11 } of dried coal.

Composition of coke:

Carbon.....	89.30	87.54
Ash.....	10.70	12.46

No. 3. *Buchanan's Mine, three miles west of Albia.* The coal has a firm structure; is black and glossy; clean; well laminated; breaking readily into layers with smooth and

regular surfaces; not thickly intersected with seams of calcareous matter. Some, however, mixed with pyrite, is visible on its edges.

The analyses give:

Moisture.....	5.16	}	Total volatile.....	45.37
Volatile combustible.....	40.21		Total combustible.....	86.09
Fixed carbon....	45.88	}	Coke.....	54.63
Ash.....	8.75			
				<hr/>
				100.00

Composition of the dried coal:

Volatile combustible.....	42.40	} Total combustible.....	90.78	
Fixed carbon.....	48.38		} Coke.....	57.60
Ash.....	9.22			
	<hr/>		100.00	

The coke is rather compact and has a brilliant lustre.

The ash is of a gray color.

Composition of the coke:

Carbon...	84.03
Ash.....	15.97
	<hr/>
	100.00

No. 4. . *Barber's Mine, nine miles northward from Albia.*

The sample is composed of thin laminæ, some of which are not more than two millimetres in thickness. The edges are glossy. Upon the surfaces is found mineral charcoal. The layers themselves are quite compact, but the number and thickness of the laminæ makes the structure of the entire mass seem rather loose. The coal soils the fingers much. Calcareous matter and pyrite are observable, but few seams penetrate to the interior.

Composition:

Moisture.....	6.04	}	Total volatile.....	48.53
Volatile combustible	42.49		Total combustible.....	92.06
Fixed carbon.....	49.57	}	Coke.....	51.47
Ash.....	1.90			
				<hr/>
				100.00

Composition of dried coal:

Volatile combustible.....	45.22	}	Total combustible.....	97.97 ^a
Fixed carbon.....	52.75			
Ash.....	2.03	}	Coke.....	54.78
	<u>100.00</u>			

Composition of coke:

Carbon.....	96.13
Ash.....	3.87

The coke has a clear metallic lustre, and is somewhat porous, The ash is of a very pale red color, light and feathery.

No. 5. *Perry's Mine, six miles northward from Albia.* The description of the coal from Barber's mine, would answer for this, except that more mineral matter seems here present.

The thickness of this bank is three and one-half feet.

Composition:

Moisture.....	4.43	}	Total volatile.....	47.72
Volatile combustible.....	42.69			
Fixed carbon.....	46.51	}	Total combustible.....	89.20
Ash.....	6.37			
	<u>100.00</u>		Coke.....	52.88

Composition of dried coal:

Volatile combustible.....	44.67	}	Total combustible....	93.34
Fixed carbon.....	48.67			
Ash.....	6.66	}	Coke.....	55.33
	<u>100.00</u>			

Composition of coke:

Carbon....	88.00
Ash.....	12.00
	<u>100.00</u>

The coke and ash are quite similar to those of Barber's mine.

No. 6. *Miller's Mine, ten miles northeast of Albia.* Coal is quite finely laminated, yet compact. It is glossy upon its edges, and has considerable mineral charcoal upon its faces. Some calcareous matter and pyrite are present; but the seams of the former appear to be mainly upon the edges of the sample, and not to penetrate into its interior.

Composition :

Moisture.....	4.90	}	Total volatile.....	48.55
Volatile combustible	43.65		Total combustible.....	91.37
Fixed carbon.....	47.72	}	Coke	51.45
Ash	3.73			
				<hr/>
				100.00

Composition of dried coal:

Volatile combustible	45.90	}	Total combustible.....	96.08
Fixed carbon.....	50.18		Coke.....	54.10
Ash	3.92	}		
				<hr/>
				100.00

Composition of coke :

Carbon.....	92.71
Ash	7.29
	<hr/>
	100.00

The coke is of a dull, lead color, rather compact. Ash of dark red color.

MARION COUNTY.

No. 1. *Sample from bottom of Bousquet's Mine, Coalport.* The coal is hard and brittle. Strata are quite irregular. Numerous thin seams of calcareous matter traverse the coal transversely to planes of stratification. Some mineral charcoal is found upon one of its faces. Sample is glossy upon its edges. The coke is compact, and has a metallic lustre. The ash is of a red color, slightly tinged with yellow.

No. 2. *Sample from the top of the same mine.* This coal

is not as glossy as that from the bottom. The seams of calcareous matter are not so distinct, and upon being freshly broken, scarcely any impurity appears, but the surface appears much like fine shale.

The coke is of a dull, lead color, and has a semi-metallic lustre. The ash is of a chocolate color.

Results of Analyses:

	No. 1.	No. 2.
Moisture	5.89	5.95
Volatile combustible	43.25	34.97
Fixed carbon.....	47.54	43.63
Ash.....	3.32	15.45
	<u>100.00</u>	<u>100.00</u>

Calculated on dried coal:

Volatile combustible	45.94	37.18
Fixed carbon.....	50.53	46.39
Ash.....	3.53	16.43
	<u>100.00</u>	<u>100.00</u>

	No. 1.	No. 2.
Total volatile.....	49.14	40.92
Total combustible.....	{ 90.79	78.60..of undried coal.
	{ 96.47	83.57..of dried coal.
Coke	{ 50.86	58.08..of undried coal.
	{ 54.06	62.82..of dried coal.

Composition of coke:

Carbon	93.47	73.90
Ash.....	6.53	26.10

A decided difference in the percentage of ash in the top and bottom samples will be noticed. The deviations from the means in the two samples were respectively, .15 and .52.

No. 3. *Sample from the top of D. Sherwood's Mine, Section 23, Township 74, Range 29.* The sample is made up of irregular masses, having linear dimensions of one-fourth to one-half an inch. The little masses seem rather loosely aggregated, yet not sufficiently so to permit crushing by pressure of hand. Mineral charcoal is present. There is but little calcareous matter in the seams. Sample has a fair,

glossy appearance. Coke is solid, with a metallic lustre. Ash is of a brick red color.

No. 4. *Sample from the bottom of the same mine.* The coal is more compact than that from the top. The sample itself—about three inches in each of its linear dimensions—seems to form one compact mass, nearly destitute of transverse seams of calcareous matter, though the edges are coated with it and ferric oxyd. The coke is of a semi-metallic lustre. The ash is of a buff color, with red tinge.

Composition:

	No. 3.	No. 4.
Moisture.....	5.62	6.12
Volatile combustible.....	36.61	31.49
Fixed carbon.....	55.97	51.70
Ash.....	1.80	10.69
	<hr/> 100.00	<hr/> 100.00

Calculated on dried coal:

Volatile combustible.....	38.80	33.54
Fixed carbon.....	59.29	55.08
Ash.....	1.91	11.38
	<hr/> 100.00	<hr/> 100.00

	No. 3.	No. 4.
Total volatile.....	42.23	37.61
Total combustible.....	{ 92.58	83.19 } of undried coal.
	{ 98.09	88.62 } of dried coal.
Coke.....	{ 57.77	62.39 } of undried coal.
	{ 61.20	66.46 } of dried coal.

Composition of coke:

Carbon.....	96.95	82.87
Ash.....	3.05	17.13
	<hr/> 100.00	<hr/> 100.00

A marked difference here appears in the amounts of ash. The deviations in the two samples were .22 and .07.

No. 5. *Sample from the top of Yanser's Mine, Marysville.* The sample is composed of laminæ of a thickness ranging from one-eighth to one fourth of an inch, and separated from each other by thin layers of mineral charcoal. The coal

soils the fingers much. There are present many thin seams of calcareous matter and some pyrite. The thickness of the bed is from five to seven feet.

The coke has a brilliant metallic lustre.

The ash is white, with a few red particles.

No. 6. *Sample from the bottom of the same mine.* The coal seems more compact than that from the top. Mineral charcoal is also largely present, and considerable calcareous matter. No pyrite observed.

The coke is similar to the preceding, except that it is a little more porous.

The ash is scarcely distinguishable from the preceding.

Composition:

	No. 5.	No. 6.
Moisture.....	5.56	5.82
Volatile combustible.....	40.38	38.56
Fixed carbon.....	50.16	48.58
Ash.....	3.90	7.04
	<hr/> 100.00	<hr/> 100.00

Composition of dried coal:

Volatile combustible.....	42.75	40.94
Fixed carbon.....	53.11	51.59
Ash.....	4.14	7.47
	<hr/> 100.00	<hr/> 100.00

	No. 5.	No. 6.
Total volatile.....	45.94	44.38
Total combustible.....	{ 90.54	87.14 } of undried coal.
	{ 95.86	92.53 } of dried coal.
Coke.....	{ 54.06	55.62 } of undried coal.
	{ 57.25	59.06 } of dried coal.

Composition of coke:

Carbon.....	92.76	87.35
Ash.....	7.24	12.65
	<hr/> 100.00	<hr/> 100.00

No. 7. *Sample from the top of Sherwood, Newman, and Ferren's Mine, Oskaloosa.* The coal is hard, compact, and

brittle, somewhat glossy, well laminated. Considerable mineral charcoal is upon the faces of the sample, and quite a number of seams of calcareous matter penetrate it. The coal is rather dusty.

The coke has a metallic lustre and is somewhat swollen. The ash is of a chocolate color.

No. 8. *Sample from the bottom of the same mine.* The seams of calcareous matter are more numerous and thicker than in the sample from the top of the mine. Otherwise, they are quite similar.

The coke is like that of preceding sample. The ash is white, with a slight gray tinge. The thickness of this bank is from five to six feet.

Results of Analyses :

	No. 7.	No. 8.
Moisture	5.73	5.38
Volatile combustible.....	46.54	39.76
Fixed carbon.....	45.60	48.07
Ash.....	2.13	6.79
	<hr/> 100.00	<hr/> 100.00

Composition of dried coal:

Volatile combustible	49.36	42.02
Fixed carbon	48.37	50.80
Ash	2.27	7.18
	<hr/> 100.00	<hr/> 100.00

	No. 7.	No. 8.
Total volatile.....	52.27	45.14
Total combustible	{ 92.14	87.83 } ..of undried coal.
	{ 98.73	92.82 } ..of dried coal.
Coke	{ 47.73	54.86 } ..of undried coal.
	{ 50.64	57.98 } ..of dried coal.

Composition of coke:

Carbon.....	95.52	87.61
Ash.....	4.48	12.39
	<hr/> 100.00	<hr/> 100.00

No. 9. *Sample from Clemen's Mine near Marysville.*
From the appearance of the sample, the coal occurs in

layers of about one inch in thickness, and composed of thin laminæ. The coal, however, is very compact. Its edges are glossy, but its faces are covered with mineral charcoal, making it quite dusty. A few seams of calcareous matter are present, as also a little pyrite.

The coke is hard and silvery. The ash is white, with a few red particles.

Composition:

Moisture	6.81	}	Total volatile.....	42.82
Volatile combustible.....	36.01		Total combustible	85.29
Fixed carbon.....	49.28	}	Coke	57.18
Ash.....	7.90			
	<u>100.00</u>			

Composition of dried coal:

Volatile combustible.....	38.64	}	Total combustible	91.53
Fixed carbon	52.89		Coke.....	61.36
Ash.....	8.47			
	<u>100.00</u>			

Composition of coke:

Carbon	86.19
Ash	13.81
	<u>100.00</u>

No. 10. *Sample from the top of a mine, near Bussing's Mill, four miles east of Knoxville.* The sample is hard and compact. It is well laminated, and rather glossy and clean, excepting upon one of its faces, where some mineral charcoal is found. There is but little calcareous matter present. Upon one of its edges is a coating of pyrite. The coke of this sample, as well as those of the two succeeding ones, is of a metallic lustre, and quite porous. The ash of the top and middle samples is red; that of the bottom very light red.

No. 11. *Sample from the middle of the above Mine.* The edges present a dull, almost ashy appearance, considerable quantities of calcareous matter and pyrite being found upon

them. Considerable mineral charcoal is present; and upon one of its faces is the best preserved specimen of this material yet observed, showing fibrous structure very distinctly. The coal breaks into splintery fragments.

No. 12. *Sample from the bottom of the same mine.* Appearance is quite similar to that from the top. Some pyrite is present upon one of its faces.

Results of Analyses:

	No. 10.	No. 11.	No. 12.
Moisture.....	6.56	6.40	5.72
Volatile combustible.....	45.29	39.35	46.30
Fixed carbon.....	44.25	40.37	45.46
Ash.....	3.90	13.88	2.52
	<hr/> 100.00	<hr/> 100.00	<hr/> 100.00

Calculated on dried coal.

Volatile combustible.....	48.44	42.04	49.11
Fixed carbon.....	47.37	43.13	48.22
Ash	4.19	14.83	2.67
	<hr/> 100.00	<hr/> 100.00	<hr/> 100.00

	No. 10.	No. 11.	No. 12.
Total volatile.....	51.85	45.75	52.02
Total combustible... {	89.54	79.72	91.76
{	95.81	85.17	97.33
Coke..... {	48.15	54.25	47.98
{	51.56	57.96	50.89

Composition of coke:

Carbon.....	91.87	74.41	94.75
Ash.....	8.13	25.59	5.25
	<hr/> 100.00	<hr/> 100.00	<hr/> 100.00

MAHASKA COUNTY.

No. 1. *Sample from the top of Burtis' Mine, Oskaloosa.* The coal is very compact, hard, and brittle. It is not very well laminated, and breaks into quite irregular fragments. It is quite clean and glossy, with no mineral charcoal or pyrite. There are some seams of calcareous matter. The

coke has a metallic lustre, and is cellular. The ash is white, with a faint red tinge.

No. 2. *Sample from the bottom of the same mine.* The sample is not as glossy as No. 1. There is considerable mineral charcoal present, upon the faces; also, calcareous matter and a little pyrite. It is well laminated. The coal is quite dusty. The coke and ash are similar to those of No. 1. The bank is four and one-fourth feet in thickness.

Composition:

	No. 1.	No. 2.
Moisture	5.23	5.38
Volatile combustible	42.27	34.03
Fixed carbon	48.00	48.60
Ash	4.50	11.99
	<hr/> 100.00	<hr/> 100.00

Composition calculated on dried coal:

Volatile combustible	44.61	35.96
Fixed carbon	50.65	51.37
Ash	4.74	12.67
	<hr/> 100.00	<hr/> 100.00

	No. 1.	No. 2.
Total volatile	47.50	39.41
Total combustible	{ 90.27	82.63 } of undried coal.
	{ 95.26	87.33 } of dried coal.
Coke	{ 52.50	60.59 } of undried coal.
	{ 55.39	64.04 } of dried coal.

Composition of coke:

Carbon	91.43	80.21
Ash	8.57	19.79
	<hr/> 100.00	<hr/> 100.00

No. 3. *Garretson's and Seever's Mine, Oskaloosa; from the upper part of the mine.* The coal is moderately firm and compact, and breaks with a tolerably smooth and clean surface. The edges of the sample are rather dull, and are covered with a thin coating of calcareous matter, mixed with a little red iron oxyd. There is a little mineral charcoal upon its faces and a few seams of calcareous matter penetrate it.

The coke is of a metallic lustre and somewhat porous.

The ash is almost white with faint yellow tinge.

No. 4. *Sample from the upper part of the same mine.* The external appearance of this coal is much like that of No. 3; but upon being broken, the fact is revealed that calcareous matter is thickly disseminated through the entire mass.

The coke is not as much swollen as that of No. 3.

The ash is of a very light gray color.

Results of Analyses:

	No. 3.	No. 4.
Moisture.....	6.14	4.66
Volatile combustible.....	44.35	35.62
Fixed carbon.....	48.29	45.00
Ash.....	1.22	14.72
	<hr/> 100.00	<hr/> 100.00

Composition of dried coal:

Volatile combustible....	47.25	37.36
Fixed carbon.....	51.46	47.20
Ash.....	1.29	15.44
	<hr/> 100.00	<hr/> 100.00

	No. 3.	No. 4.
Total volatile.....	50.49	40.28
Total combustible.....	{ 92.64 98.71	80.62 } of undried coal. 84.56 } of dried coal.
Coke.....	{ 49.51 52.75	59.72 } of undried coal. 62.64 } of dried coal.

Composition of coke:

Carbon.....	97.55	75.34
Ash.....	2.45	24.66
	<hr/> 100.00	<hr/> 100.00

No. 5. *Sample from the top of Nichol's Mine, Oskaloosa.* This coal exists in thin laminæ, some of which are not more than one-eighth of an inch in thickness, but yet the coal is tolerably compact. Some mineral charcoal and calcareous matter is present. The coke is rather solid and of metallic lustre. The ash is red, with a slight ochre tinge.

No. 3. *Sample from the bottom of the same mine.* The sample is well laminated, and cleaves readily. It is somewhat cleft by seams of calcareous matter, transverse to the planes of lamination. Some mineral charcoal is found upon faces. No pyrite observed. The coke is light and spongy. The ash is white, with a little tinge of yellow. The thickness of this bank is four feet.

Results of Analyses:

	No. 5.	No. 6.
Moisture	3.28	4.30
Volatile combustible	40.28	34.06
Fixed carbon	55.15	52.44
Ash.....	1.29	9.20
	<u>100.00</u>	<u>100.00</u>

Calculated on dried coal:

Volatile combustible	41.65	35.60
Fixed carbon	57.01	54.79
Ash.....	1.34	9.61
	<u>100.00</u>	<u>100.00</u>
Total volatile.....	43.56	38.36
Total combustible.....	{ 95.43	86.50
	{ 98.66	90.39
Coke	{ 56.44	61.64
	{ 58.35	64.40

Composition of coke:

Carbon.....	97.74	85.02
Ash.....	2.26	14.98
	<u>100.00</u>	<u>100.00</u>

No. 7. *Sample from Haddon's Bank, Oskaloosa.* The coal is not very compact, being quite easily crushed into fragments by pressure of the hand. Quite a number of seams of calcareous matter are present; also some pyrite.

The coke is spongy and brilliant.

The ash has a pale red color, with light particles.

This bank has a thickness of four feet.

The Results of the Analyses are:

Moisture.....	4.83	}	Total volatile.....	42.59
Volatile Combustible.....	37.76		Total Combustible.....	90.62
Fixed Carbon.....	52.86	}	Coke.....	57.41
Ash.....	4.55			
<hr/>				
100.00				

Composition of dried coal:

Volatile Combustible.....	39.68	}	Total Combustible.....	95.21
Fixed Carbon.....	55.53		Coke.....	60.32
Ash.....	4.79			
<hr/>				
100.00				

Composition of coke:

Carbon.....	92.15
Ash.....	7.85

No. 8. *Sample from Burns' Mine, five miles southeast of Oskaloosa.* The sample is clean and glossy upon its edges, but somewhat dusty upon its faces, where there is some mineral charcoal. It is very compact; distinctly stratified; and cleaves well. There is some calcareous matter upon its edges but no indications of the penetration by seams of its interior.

The coke is brilliant and cellular.

The ash is red.

Composition:

Moisture.....	4.01	}	Total volatile.....	51.77
Volatile combustible.....	47.76		Total combustible.....	93.83
Fixed carbon.....	46.07	}	Coke.....	48.23
Ash.....	2.16			
<hr/>				
100.00				

Composition of dried coal:

Volatile combustible.....	49.75	}	Total combustible.....	97.74
Fixed carbon.....	47.99		Coke.....	50.25
Ash.....	2.26			
<hr/>				
100.00				

Composition of coke:

Carbon	95.52
Ash.....	4.45
	<hr/>
	100.00

WEBSTER COUNTY.

No. 1. *Sample from Rees' Mine, near Fort Dodge.* This coal is not compact, but quite loose in its structure. It is rather finely laminated, and is also broken into small masses by fissures transverse to the planes of lamination. There is but little mineral charcoal present; and the coal is quite clean. Seams of calcareous matter are quite numerous.

The coke is but slightly swollen, and has a semi-metallic lustre.

The ash is gray.

No. 2. "*Lower Cannel Coal*," *from the bank of the Des Moines river, section 17, township 88, range 29.* A compact, hard coal; not very brittle; breaks into rather splintery fragments, with much dust. It is well stratified, the thickness of the layers being usually about half an inch. Upon one side are laminæ, not much thicker than sheets of paper. There is a little pyrite upon the surface and also some iron oxyd; but very little calcareous matter. The coal has a slaty appearance.

The coke is semi-metallic, not swollen.

The ash is of a chocolate color, inclining to pale red.

No. 3. *Sample from section 17, township 88, range 28.* The description of No. 2 answers well for this.

No. 4. "*Collins' Mine*," *same section, township, and range as No. 3.* The sample is not compact; creaks under pressure of the hand. It is well laminated, and the laminæ are quite thin. Considerable mineral charcoal is present, as also a few seams of calcareous matter. The coke has a metallic lustre, and is a little swollen. The ash is of a cinnamon color.

No. 5. "*Cannel Coal*," *from Rees' Mine, Fort Dodge.* The

sample is very compact, with few planes of lamination. It breaks with a conchoidal fracture. It is slaty in appearance. A few seams of calcareous matter are present. The results of the analyses show that "Bituminous Shale" would be a more appropriate name for this sample. The coke is dull, not swollen. The ash is of a very light gray color.

Results of Analyses:

	No. 1.	No. 2.	No. 3.	No. 4.	No. 5.
Moisture	14.05	10.46	10.13	13.91	9.92
Volatile combustible.	36.42	37.44	37.25	37.00	26.69
Fixed carbon	41.19	36.93	36.08	41.83	22.08
Ash	8.34	15.17	16.54	7.26	41.31
	<u>100.00</u>	<u>100.00</u>	<u>100.06</u>	<u>100.00</u>	<u>100.00</u>

Calculated on dried coal:

Volatile combustible.	42.38	41.80	41.44	42.98	29.63
Fixed carbon	47.94	41.26	40.15	48.59	24.51
Ash	9.68	16.94	18.41	8.43	45.86
	<u>100.00</u>	<u>100.00</u>	<u>100.00</u>	<u>100.00</u>	<u>100.00</u>
Volatile combustible.	50.47	47.90	47.38	50.91	36.61
	No. 1.	No. 2.	No. 3.	No. 4.	No. 5.
Total combustible.	{ 77.61	74.37	73.33	78.83	48.77
	{ 90.32	83.06	81.59	91.57	54.14
					} of undried coal.
					} of dried coal.
Coke	{ 49.53	52.10	52.62	49.09	63.39
	{ 57.62	58.20	58.56	57.02	70.37
					} of undried coal.
					} of dried coal.

Composition of coke:

Carbon	83.00	70.87	68.56	85.19	34.87
Ash	17.00	29.13	31.44	14.81	65.13
	<u>100.00</u>	<u>100.00</u>	<u>100.00</u>	<u>100.00</u>	<u>100.00</u>

WAPELLO COUNTY.

No. 1. *Sample from Brigg's Mine, near Eddyville.* This is a hard, compact coal, glossy and clean. There is a little mineral charcoal upon one of the faces of the sample. It is well laminated, but the laminæ are very closely aggregated. Upon one of its edges, is a little pyrite. Only a little calcareous matter is present, and very few seams appear to penetrate into the interior. The bank itself is four feet

in thickness. The coke is considerably swollen, quite spongy, and has a metallic lustre. The ash is of a red color.

Composition :

Moisture.....	4.07	}	Total volatile.....	54.72
Volatile combustible.....	50.65		Total combustible.....	94.55
Fixed carbon.....	43.90	}	Coke.....	45.28
Ash.....	1.38			
				<hr/>
				100.00

Composition of dried coal :

Volatile combustible.....	52.80	} Total combustible	98.56
Fixed carbon.....	45.76		} Coke . . . . .	47.20
Ash.....	<u>1.44</u>		
	100.00		

Composition of coke :

Carbon.....	96.95
Ash.....	3.05
	<hr/>
	100.00

No 2. *Sample from Brown & Godfrey's Mine, four and one-half miles northeast of Ottumwa.* This sample is composed of rudely rectangular masses, having linear dimensions of two or three inches, these masses being very firm and compact, and separated from each other by rather thick seams of calcareous matter. There are distinct marks of lamination, but the cleavage is quite imperfect. The fracture is conchoidal, and the freshly broken surface is glossy and clean. There is a little mineral charcoal upon its faces. Thickness of bank, four and one-half feet. Coke, metallic and spongy. Ash, white.

Composition :

Moisture.....	6.50	}	Total volatile.....	47.85
Volatile combustible.....	41.35		Total combustible.....	89.60
Fixed carbon.....	48.25	}	Coke.....	52.15
Ash.....	3.90			
				<hr/>
				100.00

Composition of dried coal :

Volatile combustible.....	44.22	}	Total combustible.....	95.83
Fixed carbon.....	51.61			
Ash.....	4.17	}	Coke.....	55.78
	<u>100.00</u>			

Composition of coke:

Carbon.....	92.52
Ash	<u>7.48</u>
	100.00

No. 3. *Sample from Wylie's mine near Eddyville.* A very hard, compact coal, brittle, glossy, and clean. It breaks with a conchoidal fracture, and not in the planes of lamination, which are clearly perceivable. There is some calcareous matter upon its edges, but not many seams appear to penetrate the sample. A mere trace of mineral charcoal is present. Thickness of bed, two and one-half feet. The coke has a silvery lustre, and is spongy. The ash is nearly white, with a slight gray tinge.

Composition :

Moisture.....	3.95	}	Total volatile.....	40.93
Volatile combustible.....	36.98			
Fixed carbon.....	48.71	}	Total combustible.....	85.69
Ash.....	10.36		Coke.....	59.07
	<u>100.00</u>			

Composition of dried coal :

Volatile combustible.....	38.51	}	Total combustible.	89.22
Fixed carbon.....	50.71			
Ash.....	10.78	}	Coke.....	61.49
	<u>100.00</u>			

Composition of coke :

Carbon.....	82.46
Ash.....	<u>17.54</u>
	100.00

No. 4. *Sample from the top of Allen's Mine, one-half mile north of Ottumwa.* The coal has a dull, ashy appearance. It seems tolerably compact at first sight, but a few slight blows of the hammer loosens the entire mass. The sample is well laminated and cleaves along the planes, though not with a smooth surface. But few seams of calcareous matter, and little pyrite are present. Much mineral charcoal is present. The coal is very dusty.

No. 5. *Sample from the bottom of the above Mine.* This coal presents a much better appearance than that from the top. It is quite hard and glossy; no pyrite visible; quite a number of seams of calcareous matter; some mineral charcoal on faces. It breaks into fragments, with clean glossy surfaces, and with little dust. It is well laminated and cleaves quite perfectly.

Composition:

	No. 4.	No. 5.
Moisture	5.06	3.35
Volatile combustible	27.61	46.75
Fixed carbon.....	40.32	45.04
Ash.....	27.01	4.86
	<u>100.00</u>	<u>100.00</u>

Composition of dried coal:

Volatile combustible	29.08	48.37
Fixed carbon.....	42.47	46.61
Ash.....	28.45	5.02
	<u>100.00</u>	<u>100.00</u>
Total volatile.....	32.87	50.10

	No. 4.	No. 5.
Total combustible	{ 67.93	91.79 } of undried coal.
	{ 71.55	94.98 } of dried coal.
Coke	{ 67.33	49.90 } of undried coal.
	{ 70.92	51.63 } of dried coal.

Composition of coke:

Carbon.....	59.89	90.26
Ash.....	40.11	9.74
	<u>100.00</u>	<u>100.00</u>

No. 6. *Sample from the top of Hon. C. Dudley's Mine, section 4, township 72, range 15.* The coal is jet black; glossy; very hard and compact; clean, except upon one of its faces, where there is a little mineral charcoal. It is quite finely laminated, but does not cleave well along the planes. There are a few thin seams of calcareous matter. The coal breaks with little dust and with a lustrous surface.

The coke is much swollen, porous, and metallic.

The ash is of a snuff color.

No. 7. *Sample from the bottom of the same mine.* The appearance of this coal is not as good as that from the top. It is not as free from dust, nor as compact. It is divided by seams of calcareous matter into rudely rectangular masses of perhaps one cubic inch in size. A little mineral charcoal is present, as also a little pyrite. The coal cleaves tolerably well along planes of lamination.

The coke is not swollen as much as that from the top.

The ash has a grayish white color.

The thickness of this bank is four feet.

Composition:

	No. 6.	No. 7.
Moisture.....	5.48	4.97
Volatile combustible.....	45.76	42.50
Fixed carbon.....	46.75	44.51
Ash.....	2.01	.02
	<hr/> 100.00	<hr/> 100.00

Composition of dried coal:

Volatile combustible.....	48.41	44.72
Fixed carbon.....	49.47	46.84
Ash.....	2.12	8.44
	<hr/> 100.00	<hr/> 100.00

	No. 6.	No. 7.
Total volatile.....	51.24	47.47
Total combustible.....	$\left. \begin{array}{l} 92.51 \\ 97.88 \end{array} \right\}$	$\left. \begin{array}{l} 87.01 \\ 91.56 \end{array} \right\}$ of undried coal.
Coke.....	$\left. \begin{array}{l} 48.76 \\ 51.59 \end{array} \right\}$	$\left. \begin{array}{l} 52.53 \\ 55.28 \end{array} \right\}$ of undried coal.

Composition of coke:

Carbon.....	95.88	84.73
Ash.....	4.12	15.27
	<u>100.00</u>	<u>100.00</u>

No. 8. *Sample from the top of Evans' Mine, three miles southeast of Chillicothe.* The coal is firm, compact, brittle, and glossy upon the edges. Upon the faces is a little mineral charcoal. There is some calcareous matter upon the edges; and a few seams penetrate the sample. Some pyrite and a little red iron oxyd is visible. It breaks with some dust. The coke is not much swollen, and has a metallic lustre. The ash is red.

No. 9. *Sample from the bottom of the same mine.* The coal is jet black and glossy; firm and compact. It is distinctly laminated; but not quite as plainly as the sample from the top. But little calcareous matter is present, and but few seams. A little pyrite is visible. The coal breaks with little dust. The coke is swollen and has a metallic lustre. The ash is white, with slight gray and red tints.

The Results of the Analyses are:

	No. 8.	No. 9.
Moisture.....	6.98	6.16
Volatile combustible	39.36	36.96
Fixed carbon.....	50.11	53.12
Ash.....	3.55	3.76
	<u>100.00</u>	<u>100.00</u>

Calculated on dried coal:

Volatile combustible.....	42.31	39.39
Fixed carbon.. ..	53.86	56.61
Ash.....	3.83	4.00
	<u>100.00</u>	<u>100.00</u>
Total volatile.....	46.34	43.12
Total combustible.....	{ 89.47	90.08 } of undried coal.
	{ 96.17	96.00 } of dried coal.
Coke.....	{ 53.66	56.88 } of undried coal.
	{ 57.69	60.61 } of dried coal.

Composition of coke:

Carbon.....	93.37	93.39
Ash.....	6.63	6.61
	<u>100.00</u>	<u>100.00</u>

No. 10. *Sample from the top of Marshall's Mine, eleven miles northwest of Ottumwa.* The sample is very compact, clean and glossy, and breaks with little dust. It has marks of lamination, but does not cleave readily. There is a little mineral charcoal on one of its faces; also a little calcareous matter upon its edges, and a few seams penetrating. No pyrite visible. The coke is somewhat swollen and porous, with a metallic lustre. The ash is of a light red color, with an ochre tinge.

No. 11. *Sample from the bottom of the same mine.* The coal is jet black, and very glossy, compact and brittle, breaking with little dust. It is distinctly laminated, some of the edges of the laminæ appearing more glossy than others. No mineral charcoal observed; some calcareous matter present, a few seams, and a little pyrite. The coke is not as much swollen as that from the top. The ash is light red. The thickness of the bank is five feet.

Composition:

	No. 10.	No. 11.
Moisture	5.21	5.85
Volatile combustible	42.19	39.69
Fixed carbon.....	45.51	48.77
Ash.....	7.09	5.59
	<u>100.00</u>	<u>100.00</u>

Composition of dried coal:

Volatile combustible	44.51	42.16
Fixed carbon.....	48.01	51.80
Ash.....	7.48	6.04
	<u>100.00</u>	<u>100.00</u>
Total volatile... ..	47.40	45.54

	No. 10.	No. 11.
Total combustible	{ 87.70	88.46 } of undried coal.
	{ 92.52	93.96 } of dried coal.

Coke	{ 52.60	54.46 } of undried coal.
	{ 55.49	57.84 } of dried coal.

Composition of coke:

Carbon.....	86.51	89.55
Ash.....	13.49	10.45
	<u>100.00</u>	<u>100.00</u>

No. 12. *Sample from the top of Inskeep's Mine, Bear Creek, three miles southwest of Ottumwa.* The coal is very black and glossy, hard and compact; well laminated, but not cleaving readily; quite clean upon its edges, but dusty upon its faces, where there is much mineral charcoal. There is but little calcareous matter upon the edges. A few seams penetrate the sample. No pyrite observed. The coal is very brittle, and breaks without a great amount of dust. Coke, swollen and metallic. Ash, snuff color.

No. 13. *Sample from the bottom of the same bank.* The coal is not as glossy or as clean as that from the top. More calcareous matter is present. More dust is found upon breaking. A very little pyrite observed. Coke, similar to that from the top. Ash, grayish white. The bank is from two and one-half to three and one-half feet in thickness.

The Analyses gave as results:

	No. 12.	No. 13.
Moisture	3.87	3.68
Volatile combustible.....	42.96	42.05
Fixed carbon.....	49.15	43.44
Ash.....	4.02	10.83
	<u>100.00</u>	<u>100.00</u>

Composition of dried coal:

Volatile combustible.....	44.69	43.66
Fixed carbon.....	51.13	45.11
Ash.....	4.18	11.23
	<u>100.00</u>	<u>100.00</u>

Total volatile.....	46.83	45.73
Total combustible.....	{ 92.11	85.49 } of undried coal.
	{ 95.82	88.77 } of dried coal.
Coke.....	{ 53.17	54.27 } of undried coal.
	{ 55.31	56.34 } of dried coal.

Composition of coke:

Carbon.....	92.43	80.05
Ash.....	7.57	19.95
	<hr/> 100.00	<hr/> 100.00

No. 14. *Sample from the top of Heacock's Mine, section 27, township 73, range 15.* The sample is firm and compact. The edges appear dull, being coated with calcareous matter, and some pyrite partially decomposed. No seams of calcareous matter penetrating the sample could be detected. There is considerable mineral charcoal upon the faces; and upon cleaving the coal, more of this substance may be seen along the planes of lamination. Considerable dust is formed on breaking.

The coke is somewhat swollen, porous; and has a metallic lustre.

The ash is reddish gray.

No. 15. *Sample from the bottom of the same mine.* The coal is compact and brittle, breaking with less dust than that from the top. There is some pyrite and calcareous matter upon the edges; and some seams penetrating the sample. The lamination and cleavage is similar to top sample. The coal is somewhat glossy and tolerably clean.

The coke is similar to that of No. 14. The ash is of a chocolate color.

The bank is four feet in thickness.

Composition:

	No. 14.	No. 15.
Moisture.....	5.35	3.89
Volatile combustible.....	42.41	36.94
Fixed carbon.....	45.24	40.83
Ash.....	7.00	18.34
	<hr/> 100.00	<hr/> 100.00

Composition of dried coal:

Volatile combustible.....	44.81	38.43
Fixed carbon.....	47.80	42.48
Ash.....	7.39	19.09
	<hr/> 100.00	<hr/> 100.00

	No. 14.	No. 15.
Total volatile.....	47.76	40.83
Total combustible.....	$\left\{ \begin{array}{l} 87.65 \\ 92.61 \end{array} \right.$	$\left\{ \begin{array}{l} 77.77 \text{ of undried coal} \\ 80.91 \text{ of dried coal.} \end{array} \right.$
Coke.....	$\left\{ \begin{array}{l} 52.24 \\ 55.19 \end{array} \right.$	$\left\{ \begin{array}{l} 59.17 \text{ of undried coal.} \\ 61.57 \text{ of dried coal.} \end{array} \right.$

Composition of coke:

Carbon.....	86.60	68.99
Ash.....	13.40	31.01
	<hr/> 100.00	<hr/> 100.00

WARREN COUNTY.

No. 1. *Sample from the top of Dillard's Mine, southwest quarter of section 29, township 77, range 24.* This is a hard, compact, and brittle coal, glossy upon its edges, distinctly laminated, and cleaves tolerably well; has some mineral charcoal upon one of its faces, and this substance may also be seen between the laminae; considerable calcareous matter and pyrite is present; the coal breaks with little dust; the coke is metallic and quite porous; the ash is light red.

No. 2. *Sample from the middle of the same mine.* There are hardly as many seams of calcareous matter as in No. 1; more mineral charcoal, and very little pyrite. The coke is similar to that of No. 1; the ash is nearly white.

No. 3. *Sample from the same Mine, just above "Sulphur Band," a stratum of pyrite somewhat below the middle of the bank.* The sample is dull, black, well laminated, much cleft by seams of calcareous matter, considerable of which is upon the edges. Much mineral charcoal is present, and the coal is quite dusty, and yields much dust on breaking. But very little pyrite present. Coke, similar to preceding; ash, white.

No. 4. *Sample from the same mine, below the "Sulphur Band," bottom of bank.* The coal and coke are quite similar to No. 3. The ash is of a light gray color.

The Results of the Analyses are as follows:

	No. 1.	No. 2.	No. 3.	No. 4.
Moisture.....	11.56	14.13	10.76	12.64
Volatile combustible.....	42.89	36.59	38.76	41.62
Fixed carbon.....	40.38	44.01	43.56	41.55
Ash.....	5.17	5.27	6.92	4.19
	<hr/> 100.00	<hr/> 100.00	<hr/> 100.00	<hr/> 100.00

Composition of dried coal:

Volatile combustible.....	48.49	42.61	43.43	47.64
Fixed carbon.....	45.66	51.26	48.82	47.56
Ash.....	5.85	6.13	7.75	4.80
	<hr/> 100.00	<hr/> 100.00	<hr/> 100.00	<hr/> 100.00

Total volatile.....	54.45	50.72	49.52	54.26
Total combustible.....	{ 83.27	80.60	82.32	83.17
	{ 94.15	93.87	92.25	95.20
Coke.....	{ 45.55	49.28	50.48	45.74
	{ 51.51	57.39	56.57	52.36

Composition of coke:

Carbon.....	88.65	89.31	86.29	90.84
Ash.....	11.35	10.69	13.71	9.16
	<hr/> 100.00	<hr/> 100.00	<hr/> 100.00	<hr/> 100.00

MADISON COUNTY.

Sample from Clark's Mine, North Branch. The coal appears light and porous. It has a dull, gray color; is quite lustreless. Mineral matter seems to be quite largely disseminated through it. It crumbles into small fragments under pressure of the hand, showing seams of calcareous matter.

The coke has but little lustre, and is spongy. The ash is of a pale, yellowish red color.

Results of Analyses:

Moisture.....	6.75	}	Total volatile.....	38.60
Volatile combustible.....	31.85		Total combustible.....	77.28
Fixed carbon.....	45.43	}	Coke.....	61.40
Ash.....	15.97			
	<hr/> 100.00			

Composition of dried coal:

Volatile combustible.....	34.17	} Total combustible	82.94
Fixed carbon.....	48.77		
Ash.....	17.06		
		} Coke	65.83

Composition of coke:

Carbon	72.36
Ash.....	27.64

GUTHRIE COUNTY.

No. 1. *Sample from Marshall's Mine, Long Branch.* The coal is very compact; irregularly stratified; remarkably clean; quite glossy. No pyrite visible, and very little calcareous matter. The coke has a brilliant lustre, and is quite solid. The ash is of a bright red color.

No. 2. *Sample from Wasson's Mine, on Middle Coon river, near Panora.* The coal is quite finely laminated; but compact, hard, and brittle. Numerous seams of calcareous matter are present, and considerable mineral charcoal. No pyrite observed. The coal is quite dusty. The coke is of a dull, lead color and lustre, and is somewhat spongy. The ash is gray.

No. 3. *Sample from Lonsdale's Mine, Deer Creek.* This is a very compact, clean, glossy coal, having a distinct lamellar structure, but not cleaving well. Upon one of its faces is a little mineral charcoal. The coal breaks with a conchoidal fracture, showing very few seams of calcareous matter, and no pyrite. The coke is dark colored; only semi-metallic; somewhat porous. The ash is of a very pale red color.

Composition:

	No. 1.	No. 2.	No. 3.
Moisture.....	13.39	11.90	13.22
Volatile combustible.....	34.96	35.86	37.25
Fixed carbon.....	47.54	42.98	46.83
Ash.....	4.11	9.26	2.70
	<hr/> 100.00	<hr/> 100.00	<hr/> 100.00

Composition of dried coal:

	No. 1.	No. 2.	No. 3.
Volatile combustible.....	40.38	40.70	42.92
Fixed carbon.....	56.88	48.79	53.97
Ash	4.74	10.51	3.11
	<u>100.00</u>	<u>100.00</u>	<u>100.00</u>
Total volatile.....	48.35	47.76	50.47

	No. 1.	No. 2.	No. 3.	
Total combustible.....	{ 82.50	78.84	84.08	} of undried coal.
	{ 95.26	89.49	96.89	} of dried coal.
Coke	{ 51.65	52.24	49.53	} of undried coal.
	{ 59.62	59.30	57.08	} of dried coal.

Composition of coke:

Carbon.....	92.10	82.26	94.67
Ash.....	7.90	17.74	5.33
	<u>100.00</u>	<u>100.00</u>	<u>100.00</u>

JASPER COUNTY.

Sample from Snook's Mine, two miles south of Newton. This is a rather firm and compact coal, of quite uniform structure; regularly laminated. Some calcareous matter is found upon the edges of the sample, but very few seams appear to penetrate it. Sample is not glossy, but is very slightly dusty, and destitute of mineral charcoal. The coke is rather solid, and nearly lustreless. The color of the ash is drab.

Results of Analyses:

Moisture	4.61	}	Total volatile.....	49.02
Volatile combustible... ..	44.41		Total combustible.....	87.71
Fixed carbon.....	43.30	}	Coke	50.98
Ash	7.68			
	<u>100.00</u>			

Calculated on dried coal:

Volatile combustible.....	46.56	}	Total combustible	91.95
Fixed carbon	45.39		Coke	53.44
Ash	8.05			
	<u>100.00</u>			

Composition of coke:

Carbon	84.93
Ash	15.07
	<hr/>
	100.00

ADAMS COUNTY.

No. 1. "*Fresh coal*," from *Rawson's Mine, Quincy*. This is a glossy coal, hard and brittle. Seams of calcareous matter are quite numerous. It is rather irregularly laminated. No pyrite observed. It is dusty; soiling the fingers much in handling. Some mineral charcoal is found upon its faces. The coke is semi-metallic, light, and porous. The ash is of a chocolate color, inclining to light red.

No. 2. *From the same mine, "Opened fourteen months."* The description of No. 1 answers tolerably well for this sample. The coke has a little more metallic lustre, and the ash is of an ochre color.

Results of Analyses:

	No. 1.	No. 2.
Moisture	10.41	10.29
Volatile combustible	35.13	38.32
Fixed carbon	48.53	47.22
Ash	5.93	4.17
	<hr/>	<hr/>
	100.00	100.00

Calculated on dried coal:

Volatile combustible	39.20	42.71
Fixed carbon	54.18	52.64
Ash	6.62	4.65
	<hr/>	<hr/>
	100.00	100.00

Total volatile	45.54	48.61
Total combustible	{ 83.66	85.54
	{ 93.38	95.35
Coke	{ 54.46	51.39
	{ 60.80	57.29

Composition of coke:

Carbon	89.10	91.88
Ash	10.90	8.12
	<hr/>	<hr/>
	100.00	100.00

DALLAS COUNTY.

"*Des Moines Coal Company.*" *From Redfield's Mine, near Redfield.* This coal is rather compact. Lamination is very indistinct, and cleavage scarcely perceptible. There are numerous seams of calcareous matter, running parallel to each other, and from an eighth to a fourth of an inch apart. The coal is quite clean, and no mineral charcoal or pyrite observed. The coke has a bright, metallic lustre, and is rather solid. The color of the ash is ochre.

Results of Analyses :

Moisture.....	12.83	}	Total volatile.....	50.13
Volatile combustible	37.30		Total combustible.....	83.74
Fixed carbon.....	46.44	}	Coke	49.87
Ash	3.43			
<hr/>				
100.00				

Composition of dried coal:

Volatile combustible	42.79	}	Total combustible.....	96.07
Fixed carbon.....	53.28		Coke.....	57.21
Ash	3.93	}		
<hr/>				
100.00				

Composition of coke :

Carbon.....	93.14
Ash	6.86
<hr/>	
100.00	

BOONE COUNTY.

No. 1. *Sample from the top of the Northwestern Coal Company's Mine, Moingona.* This is a hard, compact, and brittle coal. It is distinctly laminated, and cleaves well. There is considerable mineral charcoal; and the coal is quite dusty. Quite a number of seams of calcareous matter are found and some pyrite.

The coke is tolerably compact, with brilliant, metallic lustre.

The ash is red.

No. 2. *Sample from the bottom of the same mine.* The appearance of this coal and of its coke is quite similar to that of the top sample.

The color of the ash is a very bright red.

Composition:

	No. 1.	No. 2.
Moisture.....	13.23	11.51
Volatile combustible.....	37.52	38.86
Fixed carbon.....	43.69	43.74
Ash.....	5.56	5.89
	<hr/> 100.00	<hr/> 100.00

Calculated on dried coal:

Volatile combustible.....	43.25	43.91
Fixed carbon.....	50.36	49.43
Ash.....	6.39	6.66
	<hr/> 100.00	<hr/> 100.00

	No. 1.	No. 2.
Total volatile.....	50.75	50.37
Total combustible.....	$\left\{ \begin{array}{l} 81.21 \\ 93.61 \end{array} \right.$	$\left. \begin{array}{l} 82.60 \\ 93.34 \end{array} \right\} \begin{array}{l} \text{of undried coal.} \\ \text{of dried coal.} \end{array}$
Coke.....	$\left\{ \begin{array}{l} 49.25 \\ 56.75 \end{array} \right.$	$\left. \begin{array}{l} 49.63 \\ 56.09 \end{array} \right\} \begin{array}{l} \text{of undried coal.} \\ \text{of dried coal.} \end{array}$

Composition of coke:

Carbon.....	88.74	87.69
Ash.....	11.26	12.31
	<hr/> 100.00	<hr/> 100.00

GREENE COUNTY.

Sample from Bussey's Mine, southeastern part of county. The coal is rather loose, creaking under pressure of the hand, and is easily broken by slight blows of the hammer. There are present a few seams of calcareous matter, a little mineral charcoal, and some iron oxyd upon its edges. The lamination is imperfect, The coke is metallic and rather porous. The ash is very pale red.

Results of Analyses :

Moisture.....	9.92	}	Total volatile.....	54.31
Volatile combustible	44.39		Total combustible.....	87.92
Fixed carbon.....	48.53	}	Coke	45.69
Ash	2.16			
	<hr/>			
	100.00			

Composition of dried coal:

Volatile combustible.....	49.28	}	Total combustible.....	97.60
Fixed carbon.....	48.32		Coke	50.72
Ash	2.40			
	<hr/>			
	100.00			

Composition of coke:

Carbon.....	95.27
Ash	4.73
	<hr/>
	100.00

HARDIN COUNTY.

No. 1. *Sample from Buckner's Mine, near Eldora.* This is a loose coal, creaking under pressure of fingers. It is tolerably well laminated. Upon one of the faces, of the sample, exceedingly thin seams of calcareous matter, rudely parallel, run transversely to the planes of lamination at a distance from each other of from one to three millimetres ; and the little strata of coal, thus partitioned off, are cracked, transversely to these mineral seams, into little rude rectangles, not a millimetre in thickness. The coal is rather glossy. Mineral charcoal absent. The coke is a little swollen, and has a metallic lustre. The color of the ash is gray.

No. 2. *Sample "Found at Eldora."* This coal is also quite loose. No mineral charcoal. Some seams of calcareous matter. The coal is quite glossy. The coke is dark, metallic, not much swollen. The ash is of a gray color.

Composition :

	No. 1.	No. 2.
Moisture	7.92	7.92
Volatile combustible.....	42.54	40.80
Fixed carbon.....	44.72	42.82
Ash.....	4.82	8.46
	<hr/> 100.00	<hr/> 100.00

Composition of dried coal:

Volatile combustible	46.20	44.31
Fixed carbon	48.57	46.50
Ash	5.23	9.19
	<hr/> 100.00	<hr/> 100.00

	No. 1.	No. 2.
Total volatile.....	50.46	48.72
Total combustible.....	{ 87.26	83.62 } of undried coal.
	{ 94.77	90.81 } of dried coal.
Coke	{ 49.54	51.28 } of undried coal.
	{ 53.80	55.69 } of dried coal.

Composition of coke:

Carbon.....	90.23	83.42
Ash.....	9.77	16.58
	<hr/> 100.00	<hr/> 100.00

POWESHIEK COUNTY.

No. 1. *Sample from the top of Smith and Borrowman's Mine, North Skunk river.* The sample is hard, compact, glossy, and clean; but very little mineral charcoal present, and a few seams of calcareous matter. It is distinctly laminated, but does not cleave well. The coke has a brilliant lustre, swollen, and porous. The ash is gray.

No. 2. *Sample from the bottom of the same mine.* The coke is not as free from dust as that from the top; has more mineral charcoal; and the seams of calcareous matter are more numerous. The coke is similar to the preceding. The ash is gray.

TABLE OF THE PRECEDING ANALYSES: AVERAGES OF COUNTIES.

NAME OF COUNTY.	No of samples analyzed from county.	COMPOSITION OF UNDRIED COAL.						COMPOSITION OF DRIED COAL.					C' COMPOSITI'N OF COKE.	
		COMBUSTIBLE.			Fixed carbon.	Ash.	Total volatile	Total combustible.	Coke.	COMBUSTIBLE.			Ash.	Carbon.
		Moisture.	Volatile combustible							Volatile combustible	Fixed carbon,	Ash.		
Monroe.....	6	4.97	41.78	47.70	5.55	46.75	89.48	53.25	43.96	50.20	5.84	94.16	56.04	89.62
Marion.....	12	5.97	39.88	47.55	6.60	45.85	87.43	54.15	42.40	50.56	7.04	92.96	57.60	88.14
Maaska.....	8	4.73	39.52	49.55	6.20	44.25	88.07	55.75	41.48	52.00	6.52	93.48	58.52	89.37
Webster.....	4	12.14	37.03	39.01	11.82	49.17	76.04	50.83	42.15	44.49	13.36	86.64	57.85	76.91
Wapello.....	15	4.96	40.94	46.25	7.85	45.90	87.19	54.10	43.07	48.69	8.24	91.76	56.93	86.24
Warren.....	4	12.27	39.96	42.38	5.39	52.23	82.34	47.77	45.54	48.33	6.13	93.87	54.46	88.77
Madison.....	1	6.75	31.85	45.43	15.97	38.60	77.28	61.40	34.17	48.77	17.06	82.94	65.83	72.36
Guthrie.....	3	12.84	36.02	45.78	5.36	48.86	81.80	51.14	41.33	52.55	6.12	93.88	58.67	89.68
Jasper.....	1	4.61	44.41	43.30	7.68	49.02	87.71	50.98	46.56	45.39	8.05	91.95	53.44	84.93
Adams.....	2	10.35	36.72	47.88	5.05	47.07	84.00	52.93	40.96	53.41	5.63	94.37	59.04	90.49
Dallas.....	1	12.83	37.30	46.44	3.43	50.13	83.74	49.87	42.79	53.28	3.93	96.07	57.31	93.14
Boone.....	2	12.37	38.19	43.72	5.72	50.56	81.91	49.44	43.58	49.90	6.52	93.48	56.42	88.22
Greene.....	1	9.92	44.39	43.53	2.16	54.31	87.92	45.69	49.28	48.32	2.40	97.60	50.72	95.27
Hardin.....	2	7.92	41.67	43.77	6.64	49.59	85.44	50.41	45.25	47.54	7.21	92.79	54.75	86.83
Poweshiek.....	2	5.84	38.95	49.04	6.17	44.79	87.99	55.21	41.36	52.08	6.56	93.44	58.64	88.85
Mean.....		8.57	39.24	45.42	6.77	47.81	84.66	52.19	42.92	49.70	7.38	92.62	57.08	87.25

Results of Analyses:

	No. 1.	No. 2.
Moisture	5.41	6.28
Volatile combustible	41.39	36.51
Fixed carbon.....	47.91	50.16
Ash.....	5.29	7.05
	<hr/> 100.00	<hr/> 100.00

Calculated on dried coal:

Volatile combustible	43.77	38.95
Fixed carbon.....	50.64	53.52
Ash.....	5.59	7.53
	<hr/> 100.00	<hr/> 100.00

	No. 1.	No. 2.
Total volatile.....	46.80	42.79
Total combustible.....	{ 89.30	86.67 } of undried coal.
	{ 94.41	92.47 } of dried coal.
Coke	{ 53.20	57.21 } of undried coal.
	{ 56.23	61.05 } of dried coal.

Composition of coke:

Carbon	90.06	87.64
Ash.....	9.94	12.36
	<hr/> 100.00	<hr/> 100.00

By reference to the preceding table, it will be observed that great differences exist in the amount of moisture contained in the coals from the different counties. It is scarcely presumable that half this difference would exist had all the samples been subjected to the same conditions of temperature. The following statement, it is believed, will do justice to those coals in which the amount of moisture would otherwise appear much too large.

The coals from Warren county were nearly fresh from the mine, and had not been exposed to heat. The coals from Webster, Guthrie, Adams, Dallas, Boone, and Greene counties had been kept for nearly two years in a damp basement room, most of the time without fire. The other coals had been kept for two or more years in a heated apartment.

It will be noticed that great differences exist in some cases in the amount of ash contained in samples from different parts of the same mine; as, for example, the top and bottom. I find that similar differences exist in other localities. In the Illinois Report, in the analyses of coal from Collin's mine, in Mercer county, in the lower, middle, and upper parts of the seam, we find respectively 2.4, 37.2, and 9.2 per cent of ash. Other examples might be cited.

To show how the coals of this State, comprised in the preceding analyses, compare with those of Illinois. I insert the average composition of fifty-nine samples analyzed during the Geological Survey of that State. (See pages 276 and 277 of the Report of the Geology of Illinois):

Moisture.....	9.5
Volatile combustible.....	28.5
Carbon in coke.....	55.2
Ash.....	6.8
	<hr/>
	100.00
 Total volatile.....	 38.0
Total combustible.....	83.7
Coke.....	62.0

It will be noticed that the amount of moisture is a little in

favor of the Iowa coals, although it may be that, upon the whole, the Illinois coals had not been subjected to as favorable conditions in this respect. The amount of ash is almost the same in each. The amount of fixed carbon is largely in favor of Illinois; while that of the total combustible matter is in favor of Iowa.

Carbonaceous layer in the Cretaceous rocks at Woodbury, Woodbury county. The substance easily crushes; appears to have a rude stratification; is of various colors—black, brown, reddish. It gives, of volatile matter, 36.88 per cent., leaving 63.12 per cent. of red ash consisting of ferruginous and argillaceous matter. It need hardly be said that it is of little value as a fuel.

SECTION IV.

3. PEATS—CEDAR COUNTY.

No. 1. *Sample from Peat Works, near Springdale.* (The sample had been condensed.) The peat is almost black; very hard; brittle, breaking under a blow of the hammer into sharp, angular fragments, and having clean, smooth, surfaces. The surfaces are not glossy or brilliant, but when trimmed with a knife, they present considerable brilliancy. The fibres of vegetable matter are small, yet distinctly visible.

It may be stated with regard to the coke of all the peats analyzed, that they are nearly or quite destitute of metallic lustre. In some cases they have a few brilliant particles. They are always easily crushed, and are quite porous. The color of the ash of No. 1, is gray with blue tinge.

No. 2 *Sample from same locality, not pressed.* The sample is of a dark snuff color. It breaks quite readily, crushing very little. It is hard and compact; cuts with difficulty into blocks with some lustre on sides. Vegetable fibre distinct; a few, perhaps, a millimetre in diameter; but mostly much smaller. The ash is quite similar to that of preceding.

WINNEBAGO COUNTY.

No. 3. *Sample from marsh three miles east of Forrest City.* Snuff color; very slightly compressible with fingers; has a rather earthy structure; but very few fibres; breaks with some crushing. Ash, gray.

No. 1. *Sample from the north part of Twin Lakes, at a depth of six feet below surface.* Color is almost black. Quite solid, not spongy or compressible. Much earthy matter; some fibrous. Under a blow of the hammer, it crushes mainly, breaking but slightly. Ash, light gray, with greenish tinge.

WORTH COUNTY.

No. 5. *Sample from marsh, four miles south of Northwood.* Is of a snuff color; quite compact; largely composed of fibrous matter; crushes without breaking into fragments. Ash, gray, with slight green tinge.

No. 6. *Sample from marsh, three miles west of Northwood.* This peat is quite similar to No. 5. The ash is of a yellowish gray color.

No. 7. *Sample from near the top of the marsh at Silver Lake.* Snuff color; mainly fibrous, yet compact, and little compressible. It crushes under the hammer without breaking into fragments. The ash is of a very pale red color.

No. 8. *Sample from the same marsh, at a depth of six feet.* The color is much darker than that of the sample from the top. It is less fibrous and more earthy in its structure. Under blow of hammer, it breaks partially into fragments, yet crushes much. The color of the ash is gray, with a slight yellow tinge.

CERRO GORDO COUNTY.

No. 9. *Sample from the southeastern border of Clear Lake.* Snuff color; quite spongy, yielding a little under pressure of fingers; mainly composed of fine fibrous matter, with a few coarse stalks. It crushes under hammer without breaking. The ash is of a buff color.

No. 10. *Sample from Hon. C. W. Tenney's Marsh, in the northeastern corner of the county.* The peat is of a very dark color, some parts quite black. It consists principally of fine fibrous matter. It is not compressible under fingers. It partly breaks and partly crushes under hammer. The color of the ash is gray.

No. 11 *Sample from the northeastern part of Cerro Gordo county.* It is of a dark snuff color; composed mainly of fine fibrous matter, and is much like the preceding. The ash is of a bluish gray color, and contains some fine white sand.

WRIGHT COUNTY.

No. 12. *Sample from the marsh, one mile south of Belmond.* The color is almost black. Much earthy matter is present, with some fine fibrous. It is very compact, and breaks with some crushing. The ash is a shade darker than ordinary beach sand, and is highly silicious.

No. 13. *Sample from Dry Lake.* The color is nearly black. Its structure is quite like the preceding. The ash is gray.

No. 14. *Sample from the border of Wall Lake.* The sample is of a snuff color. It is somewhat spongy, and slightly compressible with fingers. It consists of both earthy and fine fibrous matter; and crushes under hammer. The ash is of a light gray color.

KOSSUTH COUNTY.

No. 15. *Sample from marsh, six miles northwestward from Algona.* The peat is of a dark snuff color. It is compact, mainly of closely packed fibres, some of them being quite coarse. It is slightly compressible, and crushes and breaks under the hammer. The ash is light gray, with a slight blue tinge.

No. 16. *Sample from Hon. A. C. Call's Marsh, Algona.*

The color is nearly black and a little mottled. It is composed mainly of fibrous matter. Rather compact. Breaks with some crushing. Ash, light gray.

No. 17. *Sample from marsh, eight miles north of Algona.* The sample seems slightly more compressible than No. 16; otherwise similar. Ash, light gray.

TABLE OF ANALYSES OF IOWA PEATS.

NO. OF ANALYSIS.	CALCULATED ON UNDRIED PEAT.				CALCULATED ON DRIED PEAT.			Specific Gravity.	No. of lbs. in 128 cubic feet.
	Moisture.	Volat- ile Combus- tible.	Fixed Carbon.	Ash.	Volat- ile Combus- tible.	Fixed Carbon.	Ash.		
1	18.62	41.82	18.97	20.59	35.39	23.31	25.80	1.30	10400
2	18.78	45.55	18.45	17.22	56.08	22.71	21.21	.79	6320
3	19.09	46.13	19.30	15.48	57.01	23.85	19.14	.45	3600
4	17.57	38.46	13.99	29.98	46.66	16.98	36.36	.66	5280
5	20.71	49.01	19.24	11.04	61.81	24.27	13.92	.32	2560
6	20.24	49.01	20.38	10.37	61.45	25.65	13.00	.32	2560
7	20.65	45.69	18.08	15.58	57.58	22.78	19.64	.40	3200
8	29.51	47.29	17.52	14.68	59.50	22.04	18.46	.52	4160
9	21.59	44.35	18.73	15.33	56.56	23.89	19.55	.37	2960
10	19.83	44.04	17.63	18.50	54.93	22.00	23.07	.48	3840
11	18.90	37.40	14.99	28.71	46.12	18.48	35.40	.50	4000
12	13.79	25.24	12.36	48.61	29.28	14.34	56.38	.71	5680
13	17.37	35.91	15.13	31.59	43.45	18.32	38.23	.79	6320
14	16.58	36.87	15.32	31.23	44.20	18.36	37.44	.55	4400
15	20.28	42.83	19.66	17.23	53.72	24.65	21.63	.49	3920
16	17.70	39.34	16.07	26.89	47.81	19.52	32.67	.54	4320
17	19.02	40.49	16.33	24.16	50.00	20.17	29.83	.54	4320
Average	18.90	41.73	17.19	22.18	51.62	21.25	27.13	.57	4560

For the sake of affording some means of comparing our peats with those of other localities, I insert a few results taken from the sources named in connection with them.

In Prof. Johnson's excellent little work on "Peat and Its Uses," we find a table of analyses of thirty-two peats from Connecticut, and one from New York, the average composition of which is as follows:

Moisture.....	19.40
Organic matter.....	54.52
Ash	26.08
	<hr/>
	100.00

The organic matter in the above corresponds to the sum of the volatile combustible and fixed carbon of the Iowa peats, which it will be observed equals 58.92. The ash, too, is about four per cent less in the peats from Iowa. It ought, however, to be stated, that a number of the Connecticut peats contain a very small percentage of ash, not over two or three per cent.

Eight Analyses of New Jersey peats, given by Prof. Cook, in his interesting report upon the geology of that State, show the following results :

Moisture	11.66
Combustible matter.....	58.28
Ash.....	30.06
	<hr/> 100.00

It will be observed that the per centage of moisture in the above peats is small, relatively. Two of them also had but 4.5 and 3.4 per cent. of ash.

It is impossible to give an exact statement of the relative values of our peats and of coal and of wood, as fuel. While it is true that the peats of the State are far inferior to coal, and somewhat inferior to good wood, it is equally true that they possess a high local value. And especially is this true in those localities situated at considerable distances from coal mines, and scantily supplied with timber; and in these localities, the peat marshes seem most widely distributed. There can be no doubt that the peat will do much to remove the disadvantages under which some portions of the State labor, caused by a scarcity of fuel.

Fossil Peat from Adair county. This is of a brown color; the fibrous matter being completely fossilized.

It contains of—

Moisture.....	9.31
Combustible matter.....	41.22
Ash, (gray).....	49.57
	<hr/> 100.00

Ancient Peat from a well near Iowa City, thirty feet below the surface. The substance is of a snuff color, and contains much woody fibre. The large amount of organic matter present was expelled, and a qualitative examination was made of the ash, which consists of silica, sulphuric acid, iron, calcium, magnesium, and traces of sodium, and chlorine.

APPENDICES.

APPENDIX A.

ELEVATION IN FEET OF POINTS ALONG THE LINES OF IOWA RAILROADS, BOTH COMPLETED AND PROJECTED.

These lists have been furnished to the office of the State Geological Survey by the different Chief Engineers and other officers of those companies. To increase the scope of interest which these lists may possess, wherever it has been found practicable to do so, the elevation of the datum line of each road or some other point along its line above the sea has been added.

DES MOINES VALLEY RAILROAD.

J. W. OTLEY, *Chief Engineer.*

[Datum line, low-water in the Mississippi river below Keokuk: its elevation above the sea 144 feet.]

	F.E.E.T.
Keokuk station, above datum line.....	32
Sand Prairie station, above datum line.....	80
Belfast station, above datum line.....	72
Croton station, above datum line.....	77
Farmington station, above datum line.....	106
Bonaparte station, above datum line.....	98
Bentonsport station, above datum line.....	122
Summit station, above datum line.....	247
Kilbourne station, above datum line.....	147
Doud's station, above datum line.....	157
Independent station, above datum line.....	170
Alpine station, above datum line... ..	178
Ottumwa station, above datum line.....	200

	FEET.
Comstock station, above datum line	242
Eddyville station, above datum line	234
Given station, above datum line.....	255
Oskaloosa station, above datum line	292
Leighton station, above datum line.....	325
Pella station, above datum line.....	434
Otley station, above datum line.....	451
Mouroe station, above datum line	480
Prairie City station, above datum line.....	491
Woodville station, above datum line.....	505
Des Moines station, above datum line.....	351
Adel station, above datum line.....	630
Perry station, above datum line.....	522
Track of Chicago and Northwestern Railway.....	616

KEOKUK NORTHERN AND IOWA NORTHERN CENTRAL RAILROADS.

P. A. DEX, *Chief Engineer.*

[Datum line, low water in the Mississippi river below Keokuk; its elevation above the sea, 444 feet, being the same datum as that of the D. V. R. R].

Station grounds at Bonaparte, above datum line.....	95
Summit, head of Cressup's creek, above datum line.....	264
Reed's creek, bottom of valley, above datum line	189
Big Mound, summit, above datum line.....	275
Little Cedar creek, bottom of valley, above datum line.....	190
Summit near Salem, above datum line....	250
Surface of low water in Skunk river at Oakland, above datum line	90
Summit between Skunk river and Big creek, above datum line	231
Surface of low water in Big creek above datum line.....	130
B. & M. Railroad track at Mt. Pleasant above datum line.....	262
Big creek, surface of low water above datum line.....	172
Summit between Big and Crooked creeks above datum line	268
Low water in Crooked creek above datum line.....	165
Summit west of Crawfordsville above datum line.....	266
Washington above datum line....	285
Surface of the water in Davis' creek above datum line.....	202
Summit between Davis' creek and English river above datum line.....	299
Low water in English river above datum line.....	134
Low water in Old Man's creek above datum line.....	147
Iowa river at crossing 1 mile below Iowa City above datum line.....	152

	FEET.
Flat ground adjoining west side University campus above datum line.....	178
Crossing of Prairie du Chien wagon road above datum line.....	282
Water in Rapid creek above datum line.....	209
Brown Summit above datum line.....	389
Hoosier creek above datum line.....	241
Summit between Hoosier creek and Prairie creek above datum line.....	373
Prairie creek above datum line.....	235
Cedar river above datum line.....	235
Northwestern depot at Cedar Rapids above datum line.....	261

IOWA CENTRAL RAILROAD.

C. W. TRACY, *Chief Engineer.*

[Datum line, an assumed point 35 feet below low water in the Des Moines river at Eddyville; say 620 feet above the sea.]

South boundary line of Iowa, grade, above datum line.....	377
Moravia above datum line	385
Grade at Albia, above datum line.....	346
Grade at B. & M. Railroad crossing, above datum line ...	329
Des Moines river at Eddyville, above datum line.....	35
Grade at Eddyville, above datum line.....	60
Des Moines Valley Railroad crossing, above datum line....	83
Grade at Oskaloosa, above datum line.....	231
Surface of water in Skunk river, above datum line.....	78
Summit between North and South Skunk rivers, natural surface, above datum line.....	240
Surface of water in North Skunk river, above datum line.....	140
Crossing of C., R. I., & P. R. R. at Grinnell, above datum line.....	401
North Bear creek, surface of water above datum line.....	300
Summit between Bear and Richland creeks, natural surface, above datum line	418
Surface of water in Richland creek, above datum line.....	245
Summit between Richland creek and Iowa river, natural surface, above datum line.....	379
Surface of water in Iowa river, above datum line.....	200
Chicago Northwestern Railway crossing, above datum line.....	209
Grade at Toledo, above datum line.....	235
Summit between Iowa and Cedar rivers, above datum line... ..	377
Grade at Cedar Falls, above datum line.....	258
High water mark in Cedar river at Cedar Falls, above datum line.....	249

BURLINGTON AND MISSOURI RIVER RAILROAD.

H. THIELSEN,* *Chief Engineer.*

[Datum line, low water in the Mississippi at Burlington; its height above the sea 486 feet.]

	FEET.
High water in the Mississippi at Burlington, above datum line.....	18
Middletown station, above datum line	220
Danville station, above datum line	210
Summit between the Mississippi and Skunk rivers half a mile west of New	
London station, above datum line.....	272
Mt. Pleasant station, above datum line.....	220
Big creek, above datum line.....	104
Low water in Skunk river, above datum line	45
Chequaque station, above datum line.....	100
Glendale station, above datum line.....	240
Summit between Skunk river and Cedar creek above datum line.....	265
Fairfield station, above datum line	262
Cedar creek, above datum line ...	130
Whitfield station, above datum line.....	172
Batavia station, above datum line	135
Agency station, (summit between Cedar creek and Des Moines river) above	
datum line	296
Ottumwa station, above datum line.	125
Des Moines river, above datum line.....	100
Chillicothe station, above datum line	140
Frederic station, above datum line. ...	230
Albia station (summit between Des Moines river and Cedar creek) above	
datum line	440
Cedar creek, above datum line ...	250
Tyrone station, above datum line.....	314
Tyrone station, above datum line.	310
Melrose station, above datum line.....	348
Russell station, above datum line.....	512
Chariton station, above datum line.....	525
Summit, between Cedar creek and White Breast river, above datum line....	528
White Breast river, above datum line.....	324
Osceola station, above datum line.....	618
Oakland station, above datum line	688
Summit between Whitebreast and Seven Mile creek, above datum line	702
Seven Mile creek, above datum line	556
Summit between Seven and Four Mile creeks, above datum line.....	644

* Mr. Thielsen furnished a nicely drawn profile of his road for this office from which these data are taken.

	FEET.
Four Mile creek, (Thayer station), above datum line	516
Summit between Four Mile creek and Grand river, above datum line.....	675
Grand river, above datum line	500
Summit between Grand river and Twelve Mile creek, (Afton station), above datum line	720
Twelve Mile creek, above datum line	603
Summit between the two great rivers, (Highland station), above datum line	794
Cromwell station, above datum line	715
Corning station, above datum line	622
Nodaway station, above datum line	575
East Nodaway river, above datum line	496
Summit between East and Middle Nodaways, above datum line.....	648
Middle Nodaway river, above datum line.....	496
Vallisca station, above datum line.....	553
West Nodaway river, above datum line.....	593
Summit between West Nodaway and Middle Tarkeo, above datum line	758
Middle Tarkeo river, above datum line	588
Summit between Middle Tarkeo and East Nishnabotany, above datum line..	695
Red Oak station, above datum line	528
East Nishnabotany river, above datum line.....	499
Summit between East Nishnabotany and Walnut creek, above datum line...	636
Walnut station, above datum line	535
Walnut creek, above datum line.....	512
Summit between Walnut creek and West Nishnabotany, above datum line..	665
Harmony station, above datum line	535
West Nishnabotany river, above datum line	452
Summit between West Nishnabotany and Silver creek, above datum line....	497
Silver creek (at Silver creek station), above datum line.....	452
Summit between Silver and Elm creeks (Louden Station) above datum line..	700
Elm creek, above datum line.....	608
Summit between Elm and Key creeks, above datum line.....	700
Glenwood station, above datum line	474
Pacific station (on C. B. and St. Jo. R. R.) above datum line.....	444
Missouri river (high water), above datum line.....	438
Missouri river (low water), above datum line.....	421

The range between high and low water in the two great rivers is accurately stated by Mr. Thielsen, as follows:

	FEET.
Range between high and low water in the Mississippi at Burlington.....	17.93
Range between high and low water in the Missouri at Plattsmouth.....	16.96

CHICAGO, ROCK ISLAND, AND PACIFIC RAILROAD.

E. H. JOHNSON, *Chief Engineer.*

[Datum line, low water in the Mississippi river at Davenport; its elevation above the sea, say 528 feet.]

	FEET.
Davenport station, above datum line	32
Top of bluff near the city, above datum line	165
Highest point between Davenport and Walcott, above datum line.....	213
Walcott station, above datum line.....	187
Fulton station, above datum line	212
Durant station, above datum line.....	166
Wilton station, above datum line.....	126
Moscow station, above datum line	106
Surface of water in Cedar river, above datum line.....	75
Cedar river bridge, above datum line.....	99
West Liberty station, above datum line.....	120
Downey station, above datum line.....	137
Iowa City station, above datum line.....	125
Iowa river, bed of stream, above datum line	73
Top of valley-side (west side), above datum line	188
Oxford station, above datum line.....	174
Homestead station, above datum line.....	320
Victor station	260
Brooklyn station, above datum line.....	290
Grinnell station, above datum line.....	465
Kellogg station (in valley of North Skunk river), above datum line	293
Newton station, above datum line.....	412
Water in Skunk river, 5 miles east of Colfax station, above datum line.....	225
Railroad grade at same place, above datum line	235
Mitchellville station, above datum line.....	420
Water in Des Moines river at Des Moines, above datum line.....	230
Des Moines station, above datum line.....	254
Crossing of Coon river, 5 miles west of Des Moines, above datum line.....	310
Surface of water at the same place, above datum line.....	285
De Soto station, in valley of Bulger creek, above datum line.....	340
Earlham station station, on Quaker divide, above datum line	560
Dexter station, on Quaker divide, above datum line.....	600
Guthrie station, above datum line	723
Casey station, (forks of Middle river, on section 3, township 77, range 32), above datum line.....	680
Great Watershed, (section 3, township 77, range 33), above datum line.....	917
Railroad grade at same point.....	870
Turkey creek valley, at Beason's, above datum line.....	710
Turkey creek valley, two miles east of Grove City, above datum line.....	642

	FEET.
Grove City station, above datum line.....	725
East Nishnabotany, at the mouth of Troublesome and Buck creeks, above datum line.....	600
Summit between Indian creek and East Nishnabotany, above datum line....	760
Railroad grade at same point, above datum line	727
Indian creek, at the crossing, on section 18, township 77, range 37, above datum line.....	710
Bottom of the creek, at the same place, above datum line.....	695
High ground between West Nishnabotany and Indian creek, above datum line	790
Highest grade between West Nishnabotany and Indian creek, above datum line	764
West Nishnabotany, at the crossing on section 8, township 77, range 39, above datum line	588
Bottom of stream at same place, above datum line	570
Summit, between West Nishnabotany and Silver creek, above datum line ...	780
Railroad grade at same place, above datum line	743
Crossing of Silver creek, on section 27, township 78, range 40, above datum line	673
Bottom of the creek at the same place, above datum line	655
Summit, between Silver and Keg creeks, above datum line.....	785
Highest grade at same place, above datum line	763
Crossing of Keg creek, on section 15, township 77, range 41, above datum line	634
Water in narrow channel of creek, above datum line.....	620
Summit, between Mosquito and Keg creeks, above datum line.....	750
Railroad grade at same place, above datum line	698
Water in Mosquito creek, above datum line	530
Grounds at Council Bluffs, on section 25, township 77, range 42, above datum line	432

DAVENPORT & ST. PAUL RAILROAD.

E. BALDWIN, *Chief Engineer.*

[Datum line, highwater mark in the Mississippi river at Davenport; its elevation above the sea, say 545 feet above the sea.]

	FEET.
Summit between the Mississippi river and Duck creek, above datum line ...	120
Surface of water in Duck creek, on section 19, 78, 3, east, above datum line..	46
Surface 10½ miles from Davenport, on section 10, 79, 1, east, above datum line	192
Summit between Duck and Mud creeks, on section 18, 79, 3, east, above datum line.....	204
Surface of water in Mud creek, on section 29, 80, 2, east, above datum line ..	78
Summit between Mud and Big creeks, on section 19, 80, 1, east, above datum line	166
Surface of water in Big creek, on section 35, 81, 1, east, above datum line ...	82
Crossing track of Chicago & Northwestern Railway at Wheatland, above datum line	105

	FEET.
Water in Wapsipinicon at crossing at Toronto, above datum	111
Summit between Wapsipinicon river and south Fork of Maquoketa, above datum line.....	304
Surface of water in Bear creek, on section 28, 84, 1, east, above datum line..	194
Summit between Mill Rock and Canton, above datum line	305
Surface of water in South Fork of Maquoketa, at Canton, above datum line.	136
Summit between North and South Forks of Maquoketa, above datum line..	375
Cascade (town site), above datum line.....	207
Surface of water in North Fork of Maquoketa, section 30, 87, 2, west, above datum line.....	230
Crossing track of Dubuque Southwestern Railroad at Sand Springs, above datum line....	375
Summit between North and South Forks of Maquoketa from Wilson's mill to Hopkinton, above datum line.....	395
Hopkinton, surface of water in South Fork, above datum line.....	263
Crossing of Dubuque and Sioux City Railroad at Delaware Center, above datum line	520
Delaware Center, general surface of town site, above datum line	543
Summit between South Fork of Maquoketa and Turkey river, above datum line	605
Strawberry Point, section 22, 91, 6, west, above datum line.....	655
Summit one mile west of Strawberry Point, above datum line.....	680
Water in Volga river, near Fayette, section 28, 93, 8, west, above datum line.	427
Summit, between Volga and Turkey rivers, section 21, 94, 9, west, above datum line	659
Crane creek, section 36, 95, 10, west, above datum line.	440
Little Turkey, section 14, 96, 11, above datum line.....	501
Summit, between Little and Big Turkey rivers, above datum line.....	716
Turkey river, section 32, 99, 11, west, above datum line	580
Cresco, on summit between Turkey and Iowa rivers, above datum line....	736
McGregor and St. Paul Railroad track at Cresco, above datum line	737

IOWA DIVISION OF CHICAGO AND NORTH-WESTERN RAILWAY.

BY W. W. WALKER, *Vice President and Chief Engineer of C. R. & M. R. R.**

[Datum line, level of Lake Michigan; its elevation is 578 feet above the sea].

	FEET.
High water, A. D. 1864, in the Mississippi at Clinton, above datum line	4
Clinton bridge, across the Mississippi, above datum line.....	22
Summit, between Mississippi and Wapsipinicon rivers, above datum line....	147

* The elevations between Clinton and Cedar Rapids were furnished by I. B. Howe, Esq., Asst. Gen. Supt., C and N. W. R. All others are taken from profiles furnished this office by Vice President Walker.

	FEET.
Wapsipinicon bridge, at crossing, above datum line.....	98
Water in Wapsipinicon, at same place, above datum line.....	89
Summit, between Wapsipinicon and Cedar rivers, above datum line	332
Water in Cedar river at Cedar Rapids, above datum line.....	139
Fairfax station, above datum line.....	202
Norway station, above datum line.....	230
Blairstown station, above datum line.....	272
Summit, between Prairie and Buckeye creeks, above datum line.....	335
Buckeye creek, above datum line.....	242
Belleplaine station, above datum line.....	253
Salt creek, above datum line	214
Chelsea station, above datum line	220
Toledo station, above datum line.....	249
Iowa river, above datum line.....	269
Orford station, above datum line.....	286
Indian creek, above datum line	296
Le Grand station, above datum line	371
Timber creek, above datum line.....	300
Marshall station, above datum line	328
Linn creek, above datum line	352
State Centre station, above datum line.....	504
Summit between Linn and Dey creeks, above datum line	555
Colo station, above datum line.....	477
Dey creek, above datum line.....	425
Nevada station, above datum line.....	435
West Indian creek, above datum line.....	413
Skunk river, above datum line	327
Ames station, above datum line....	356
Squaw Fork, above datum line.....	337
Summit between Skunk and Des Moines rivers, above datum line	610
Boone station, above datum line ...	373
Des Moines river, above datum line.....	327
Moingona station, above datum line.....	341
Summit between Des Moines river and East Branch Beaver creek, above datum line.....	535
East Branch Beaver creek, above datum line....	521
Beaver station (water in Beaver creek), above datum line.....	461
Hagar station, above datum line.....	467
Hardin's creek, above datum line.....	448
New Jefferson, above datum line	491
Summit between Hardin's creek and Coon river, above datum line	508
Coon river, above datum line.....	439
Scranton station, above datum line.....	511
Glidden station, above datum line.....	660

	FEET.
Carroll station, above datum line.....	694
East Side station, above datum line	712
Tip Top station, above datumline	859
West Side station, above datum line.....	761
Vail station, above datum line.....	694
Dennison station, above datum line.....	691
Paradise station, above datum line.....	568
Dunlap station, above datum line.....	581
Woodbine station, above datum line.....	492
Missouri Valley station, above datum line.....	440
Honey creek station, above datum line.....	442
Crescent station, above datum line	429
Council Bluffs station, above datum line.....	420
Missouri river (low water), above datum line.....	409

SIoux CITY AND PACIFIC RAILROAD.

L. BURNETT, *Assistant Superintendent.*

[Datum line, 215 feet above the level of Lake Michigan; elevation of datum line above the sea, 793 feet.]

	FEET.
Missouri Valley Junction sec. 15, 78, 44, above datum line.....	225
California Junction, sec. 15, 78, 45, above datum line.....	225
Modale station, sec. 30, 79, 44, above datum line.....	225
Mondamin station, sec. 25, 80, 45, above datum line.....	234
Little Sioux station, section 33, 81, 45, above datum line.....	244
Blencoe station, section 9, 82, 45, above datum line	264
Onawa station, section 4, 83, 45, above datum line	271
Sloan station, section 29, 86, 46, above datum line.....	294
Sergeant's Bluffs station, section 31, 88, 47, above datum line	316
Floyd's Bluffs, station, section 1, 88, 48, above datum line	406
Sioux City, grade on the steamboat levee, above datum line	322
Low water in Missouri river at Sioux City, above datum line.....	300

DUBUQUE AND SIOUX CITY RAILROAD.

J. E. AINSWORTH, *Chief Engineer.*

[Datum line, low water in the Mississippi at Dubuque; its elevation above the sea say 610 feet.]

	FEET.
Farley Junction—summit between the Mississippi and North Fork of Maquoketa river, above datum line	531
Dyersville station, North Fork of Maquoketa, above datum line	345
Summit, between North and South Forks of Maquoketa, above datum line .	497

	FEET.
Manchester station, South Fork of Maquoketa, above datum line.....	327
Summit, between South Fork of Maquoketa and Buffalo creek, above datum line	521
Buffalo creek, above datum line.....	406
Winthrop station—summit between Buffalo creek and Wapsipinicon river, above datum line	469
Independence, Wapsipinicon river	313
Summit, between Wapsipinicon and Cedar rivers, above datum line	417
Cedar river, at Waterloo, above datum line.....	253
Summit between Cedar and Iowa rivers, above datum line	610
Iowa river, at Iowa Falls, above datum line.....	460
Summit between the Iowa and South Fork of Iowa rivers above datum line.	593
South Fork of Iowa river above datum line.....	548
Summit between South Fork of Iowa and Boone rivers above datum line ...	649
Webster City, Boone river, above datum line.....	428
Summit between Boone and Des Moines rivers above datum line ...	560
Fort Dodge, Des Moines river, above datum line.....	390
Summit between Des Moines and Coon rivers above datum line.....	719
Coon river above datum line.....	668
Summit between Coon and Little Sioux rivers above datum line.....	908
Little Sioux river at Cherokee village above datum line....	565
Summit between Little Sioux and Floyd rivers above datum line.....	877
Floyd river above datum line.....	555
Missouri river, at Sioux City (See <i>Sioux City and Pacific R. R.</i>)	

CEDAR FALLS & MINNESOTA RAILROAD.

J. E. AINSWORTH, *Chief Engineer.*

[Datum line, low water in the Mississippi river, at Dubuque; its elevation above the sea, say 610 feet.]

	FEET.
Water in Cedar river, at Cedar Falls, above datum line.....	267
Junction Station, above datum line.....	282
Janesville Station above datum line.....	300
Water in the river at Janesville Station above datum line.....	282
Summit between Janesville and Waverly above datum line.....	421
Waverley Station above datum line.....	350
Summit beyond Waverly above datum line.....	390
Plainfield station above datum line.....	354
Nashua station above datum line.....	383
River at Nashua above datum line.....	356
Summit station between Nashua and Charles City above datum line....	492

	FEET.
Charles City station above datum line.....	427
Floyd station above datum line.....	515
Osage station above datum line.....	586
Mitchell station above datum line.....	610
St. Ansgar station above datum line.....	587
Surface of water at Mary's Ford above datum line.....	538
North boundary of State above datum line	600

PROJECTED RAILROAD FROM JANESVILLE UP THE VALLEY OF
SHELLROCK RIVER *via* ROCK GROVE, MARY'S FORD, Etc.

J. E. AINSWORTH, *Chief Engineer.*

[Datum line, low water in the Mississippi, at Dubuque; its elevation above the sea,
say 610 feet.]

	FEET.
Janesville station above datum line.....	300
Summit between Janesville and Shellrock village above datum line.....	362
Shellrock village above datum line.....	328
Summit between Shellrock village and Beaver creek above datum line.....	373
Water in Beaver creek above datum line.....	330
Clarkesville station above datum line.....	350
Water in Flood creek above datum line.....	346
Elm Springs station above datum line	373
Marble Rock station above datum line	440
Rockford station above datum line.....	445
Rock Grove station above datum line.....	540
Summit between Rock Grove and Flood creek above datum line.....	554
Water in Flood creek above datum line.....	542
Summit between Flood and Rock creeks above datum line.....	638
Water in Rock creek, above datum line.....	592
Summit, between Rock creek and Deer creek, above datum line....	627
Water in Deer creek, above datum line.....	564
Summit, between Deer creek and Mary's ford, above datum line.....	612
Water in Cedar river, at Mary's ford, above datum line	538
Water in Otter creek, above datum line	550
State boundary line, above datum line.....	600

PARALLEL SURVEYS NEAR THE LINE OF THE DUBUQUE AND SIOUX CITY RAILROAD.

[Furnished by L. BURNETT, Asst. Supt. Sioux City and Pacific Railway.]

(Datum line, from Sioux City to Storm Lake, 215 feet above Lake Michigan. Datum line from Storm Lake to Fort Dodge, level of Lake Michigan; elevation of Lake Michigan above the sea, 578 feet.

	FEET.
Floyd river, section 16, 92, 45, above datum line.....	450
Summit, between Floyd river and Whisky slough, section 1, 92, 44, above datum line.....	670
Whisky slough, section 2, 92, 43, above datum line	595
West Fork and Whisky slough divide, above datum line.....	675
West Fork of Little Sioux, section 1, 92, 42, above datum line	585
Summit between the West Fork and Little Sioux, section 10, 92, 41, above datum line	675
Low water in Little Sioux, section 34, 91, 40, above datum line	370
Summit, between Little Sioux and Maple rivers, section 6, 91, 39, above datum line	575
Maple river, low water section 4, 91, 39, above datum line.....	548
Great Watershed, section 27, 91, 38, above datum line.....	728
Storm Lake, surface of water, above datum line.....	816
[Datum line level of Lake Michigan.]	
Half a mile north of Storm Lake, section 3, 91, 37, above datum line.....	870
Surface in ranges 36 and 37, above datum line.....	884
West branch of Coon river in ranges 35 and 36, above datum line	745
Surfaces in ranges 34 and 35, above datum line.....	882
Summit between East and West Forks of Coon river, section 18, 90, 34, above datum line.....	872
Water in Cedar creek, section 22, 90, 34, above datum line.....	77 ₂
Surface in ranges 33 and 34, above datum line	882
Surface in ranges 32 and 33, above datum line.....	792
Surface in ranges 31 and 32, above datum line.....	872
Surface in ranges 30 and 31, above datum line.....	752
Surface in ranges 29 and 30, above datum line.....	684
Des Moines river, on section 19, 89, 28, above datum line.....	382

DUBUQUE & MINNESOTA RAILWAY.

J. E. AINSWORTH, *Chief Engineer.*

(Datum line, low water in the Mississippi at Dubuque; its elevation above the sea, say 610 feet.)

	FEET.
Mouth of Turkey river, above datum line	18
Elkader, water above the mill-dam, above datum line	136 $\frac{1}{2}$
Mouth of Crane creek, water above mill-dam, above datum line.....	401

	FEET.
Water in Crane creek, at crossing above datum line.....	579
Summit between Crane creek and Wapsipinicon river, above datum line..	809½
Wapsipinicon river, high water, above datum line... ..	660
Summit between Wapsipinicon and Little Cedar rivers, above datum line.	707½
Little Cedar river, high water, above datum line	610
Summit-crossing, bend of Little Cedar, above datum line.....	677½
Cedar river, high water, above datum line	561
Summit between Cedar river and Deer creek, above datum line.....	633
Deer creek, high water, above datum line	605
Summit between Deer creek and Shellrock river, above datum line.....	653
Shellrock river, high water, above datum line.....	619
Summit between Shellrock and Elk creek, above datum line.....	708
Elk creek, above datum line.....	666
Summit between Elk and Lime creeks, above datum line.....	751½
Lime creek, above datum line.....	657
Summit between Lime and Rice creeks, above datum line.....	676
Rice creek, above datum line	428
Summit between Rice creek and Blue Earth river, above datum line.....	469
Blue Earth river, high water, above datum line	399½
Bed of Blue Earth river at same point, above datum line.....	371

CENTRAL RAILROAD OF IOWA.

P. L. GIBBS, *Chief Engineer.*

[Datum line, crossing of the track of the Chicago and Northwestern Railway at Marshalltown; elevation of datum line above the sea, 908 feet.]

	FEET.
Crossing of Iowa river on section 1, 84, 18, height of water (medium stage), below datum line.....	14
Albion station, above datum line	38
Albion village, above datum line.....	63
Liscomb station, above datum line.....	107
Liscomb village, above datum line.....	117
Crossing of Iowa river, low water level on section 27, 19, 5.....	29
Union station, above datum line....	45
Union village, above datum line.....	45
Crossing of South Fork of Iowa river on section 32, 87, surface of low water above datum line.....	35
Eldora station, above datum line	114
Eldora village, above datum line	144
Steamboat Rock station, above datum line.....	116
Steamboat Rock village, above datum line.....	150
Water in Iowa river at Steamboat Rock, above datum line.....	100
Ackley station, above datum line.....	236

APPENDIX B.

CATALOGUE OF THE BIRDS OF IOWA.

BY J. A. ALLEN.

NOTE.—In the following catalogue, two hundred and eighty-three species are enumerated. A few of them are to be regarded rather as wanderers from their ordinary habitats than as regular inhabitants of the State of Iowa. These are chiefly winter visitors from the North; some, however, are stragglers from the South, and others from the Western Plains. Those marked with a star, have been observed by the writer within or near the borders of the State in the breeding season. These embrace all the more common species that breed in the State, but a considerable number of others are also regular summer residents. A few species, not included in the list, may occur as rare stragglers from the Plains or from the North.

FAMILY TURDIDÆ—THRUSHES.

1. **Turdus migratorius*, Linn—Robin.
2. *Turdus naevius*, Gmelin—Varied Thrush.
3. **Turdus mustelinus*, Gmelin—Wood Thrush.
4. *Turdus Pallasi*, Cab—Hermit Thrush.
5. **Turdus fuscescens*, Steph—Wilson's Thrush.
6. *Turdus Swainsonii*, Cab—Swainson's Thrush.
7. *Mimus polyglottus*, Boie—Mocking Bird.
8. **Galeoscoptes carolinensis*, Cab—Cat Bird.
9. **Harporhynchus rufus*, Cab—Brown Thrush.

FAMILY SYLVIADÆ—WARBLERS.

10. *Regulus satrapa*, Licht—Golden-crested Kinglet.
11. *Regulus calendula*, Licht—Ruby-crested Kinglet.
12. *Poliophtila cœrulea*, Sclat—Blue-gray Gnatcatcher.

FAMILY SAXICOLIDÆ—BLUE-BIRDS and STONE-CHATS.

13. *Sialia sialis*,* Haldeman—Blue-bird.

FAMILY PARIDÆ—TITMICE.

14. **Parus atricapillus*, Linn—Black-capped Titmouse, or Chickadee.
15. *Lophophanes bicolor*, Bonap—Crested Titmouse.

FAMILY CERTHIADÆ—CREEPERS.

16. **Certhia familiaris*, Linn—Brown Creeper.

FAMILY SITTIDÆ—NUTHATCHES.

17. **Sitta carolinensis*, Gmelin—White-breasted Nuthatch.
18. *Sitta canadensis*, Linn—Red-breasted Nuthatch.

FAMILY TROGLODYTIDÆ—WRENS.

19. **Troglodytes ædon*, Vieill—House Wren.
20. *Anorthoura hyemalis*, Rennie—Winter Wren.
21. *Telmatodytes palustris*, Bonap—Long-billed Marsh Wren.
22. **Cistothorus stellaris*, Cab—Short-billed Marsh Wren.
23. *Thryothorus ludovicianus*, Bonap—Carolina Wren.

FAMILY MOTACILLIDÆ—WAGTAILS.

24. *Anthus ludovicianus*, Licht—Tit Lark.

FAMILY SYLVICOLIDÆ—WOOD-WARBLERS.

25. **Mniotilta varia*, Vieill—Black-and-White Creeper.
26. *Parula americana*, Bonap—Blue-yellow-backed Warbler.
27. *Prothonotaria citrea*, Baird—Prothonotary Warbler.
28. **Geothlypis trichas*, Cab—Maryland Yellow-throat.
29. *Geothlypis philadelphia*, Baird—Mourning Warbler.
30. *Oporornis agilis*, Baird—Connecticut Warbler.
31. *Oporornis formosus*, Baird—Kentucky Warbler.
32. **Helminthophaga ruficapilla*, Baird—Nashville Warbler.
33. *Helminthophaga celata*, Baird—Golden-crowned Warbler.
34. *Helminthophaga peregrina*, Cab—Tennessee Warbler.
35. *Helminthophaga chrysoptera*, Baird—Golden-winged Warbler.
36. *Helminthophaga pinus*, Baird—Blue-winged Yellow Warbler.
37. *Helminthus vermivorus*, Bonap—Worm-eating Warbler.
38. *Perissoglossa tigrina*, Baird—Cape May Warbler.
39. *Dendroica virens*, Baird—Black-throated Green Warbler.
40. *Dendroica caerulescens*, Baird—Black-throated Blue Warbler.
41. *Dendroica coronata*, Gray—Yellow-crowned Warbler.
42. *Dendroica Blackburnia*, Baird—Blackburnian Warbler.
43. *Dendroica castanea*, Baird—Bay-breasted Warbler.
44. *Dendroica pinus*, Baird—Pine Warbler.
45. **Dendroica pennsylvanica*, Baird—Chestnut-sided Warbler.
46. **Dendroica cerulea*, Baird—Blue Warbler.
47. *Dendroica striata*, Baird—Black-capped Warbler.
48. **Dendroica aestiva*, Baird—Yellow Warbler.
49. *Dendroica maculosa*, Baird—Black and Yellow Warbler.

- 50. *Dendroica palmarum*, Baird—Yellow Red-poll Warbler.
- 51. *Dendroica discolor*, Baird—Prairie Warbler.
- 52. *Dendroica dominica*, Baird—Yellow-throated Warbler.
- 53. **Seiurus aurocapillus*, Swain—Golden-crowned Wagtail.
- 54. **Seiurus noveboracensis*, Nutt—New York Water Wagtail.
- 55. *Seiurus ludovicianus*, Bonap—Louisiana Water Wagtail.
- 56. *Wilsonia pusilla*, Bonap—Green Black-capped Warbler.
- 57. *Wilsonia mitrata*, Bonap—Hooded Warbler.
- 58. *Euthlypis canadensis*, Cab—Canada Warbler.
- 59. **Setophaga ruticilla*, Swain—Redstart.
- 60. **Icteria virens*, Baird—Yellow-breasted Chat.

FAMILY HIRUNDINIDÆ—SWALLOWS.

- 61. **Hirundo horreorum*, Barton—Barn Swallow.
- 62. **Petrochelidon lunifrons*, Baird—Cliff Swallow.
- 63. *Tachycineta bicolor*, Cab—White-bellied Swallow.
- 64. **Progne subis*, Baird—Purple Martin.
- 65. **Cotyle riparia*, Boie—Sand Martin; Bank Swallow.
- 66. *Steligidopteryx serripennis*, Baird—Rough-winged Sand Martin.

FAMILY VIREONIDÆ—VIREOS.

- 67. *Vireo noveboracensis*, Bonap—White-eyed Vireo.
- 68. *Vireo Bellii*, Aud—Bell's Vireo.
- 69. **Vireosylvia olivacea*, Bonap—Red-eyed Vireo.
- 70. *Vireosylvia philadelphica*, Cass—Brotherly-love Vireo.
- 71. **Vireosylvia gilva*, Cass—Warbling Vireo.
- 72. *Laniivireo flavifrons*, Baird—Yellow-throated Vireo.
- 73. *Laniivireo solitarius*, Baird—Solitary Vireo.

FAMILY AMPELIDÆ—WAX-WINGS.

- 74. **Ampelis cedrorum*, Bonap—Cedar Bird; Wax-wing.
- 75. *Ampelis garrula*, Bonap—Northern Wax wing.

FAMILY LANIIDÆ—SHRIKES.

- 76. *Collurio borealis*, Baird—Northern Shrike.
- 77. **Collurio excubitoroides*, Baird—White-rumped Shrike.

FAMILY TANAGRIDÆ—TANAGERS.

- 78. **Pyranga rubra*, Vieill—Scarlet Tanager.
- 79. *Pyranga aestiva*, Vieill—Summer Red Bird.

FAMILY ALAUDIDÆ—LARKS.

- 80. *Eremophila alpestris*, Boie—Horned Lark.

FAMILY FRINGILLIDÆ—SPARROWS.

81. *Hesperiphona vespertina*, Bonap—Evening Grosbeak.
82. *Pinicola enucleator*, Vieill—Pine Grosbeak.
83. *Carpodacus purpureus*, Gray—Purple Finch.
84. **Astragalinus tristis*, Cab—Yellow Bird ; Goldfinch.
85. *Chrysomitris pinus*, Bonap—Pine Finch.
86. *Curvirostra americana*, Wilson—Red Crossbill.
87. *Curvirostra leucoptera*, Wilson—White-winged Crossbill.
88. *Ægiolhus linaria*, Cab—Redpoll.
89. *Plectrophanes nivalis*, Meyer—Snow Bunting.
90. *Centrophanes lapponicus*, Kaup—Lapland Bunting.
91. *Centrophanes pictus*, Cab—Painted Bunting.
92. *Centronyx Bairdii*, Baird—Baird's Sparrow.
93. **Passerculus savanna*, Bonap—Savannah Sparrow.
94. **Poocates gramineus*, Baird—Grass Sparrow ; Grass Finch.
95. **Coturniculus passerinus*, Bonap—Yellow-winged Sparrow.
96. *Coturniculus Henslowii*, Bonap—Henslow's Sparrow.
97. **Chondestes grammacus*, Bonap—Lark Sparrow ; Lark Finch.
98. *Zonotrichia leucophrys*, Swain—White-crowned Sparrow.
99. *Zonotrichia querula*, Gamb—Harris's Sparrow.
100. *Zonotrichia albicollis*, Bonap—White-throated Sparrow.
101. *Junco hyemalis*, Sclat—Snow Bird.
102. *Spizella monticola*, Baird—Tree Sparrow.
103. *Spizella pusilla*, Bonap—Wood Sparrow ; Field Sparrow.
104. *Spizella pallida*, Bonap—Western Field Sparrow
105. *Spizella socialis*, Bonap—Chipping Sparrow.
106. **Melospiza melodia*, Baird—Song Sparrow
107. *Melospiza palustris*, Baird—Swamp Sparrow.
108. *Melospiza Lincolnii*, Baird—Lincoln's Sparrow.
109. *Passerella iliaca*, Swain—Fox-colored Sparrow.
110. **Euspiza americana*, Bonap—Black-throated Sparrow ; Black-throated
Bunting.
111. **Hedymeles ludoviciana*, Cab—Rose-breasted Grosbeak.
112. *Guiraca caerulea*, Swain—Blue Grosbeak.
113. **Cyanospiza cyanea*, Baird—Indigo Bird.
114. *Cardinalis virginianus*, Bonap—Cardinal Bird.
115. *Pipilo erythrophthalmus*, Vieill—Towhe ; Chewink.

FAMILY ICTERIDÆ.—BLACKBIRDS AND ORIOLES.

116. *Dolichonyx oryzivorus*, Swain—Bobolink.
117. **Molothrus pecoris*, Swain—Cow Black Bird.
118. **Agelaius phœnicens*, Vieill—Red-winged Blackbird.
119. **Xanthocephalus icterocephalus*, Baird—Yellow-headed Blackbird.
120. **Sturnella magna*, Swain—Meadow Lark.

- 121. **Icterus spurius*, Bonap—Orchard Oriole.
- 122. **Icterus baltimore*, Daud—Baltimore Oriole.
- 123. *Scolecophagus ferrugineus*, Swain—Rusty Blackbird; Rusty Grakle.
- 124. **Quiscalus versicolor*, Vieill—Crow Blackb'd; Purple Grakle.

FAMILY CORVIDÆ.—CROWS AND JAYS.

- 125. *Corvus carnivorus*, Bartram—Raven.
- 126. *Corvus americanus*, Aud—Crow.
- 127. *Pica hudsonica*, Bonap—Magpie.
- 128. **Cyanura cristata*, Swain—Blue Jay.

FAMILY TYRANNIDÆ.—TYRANT FLYCATCHERS.

- 129. **Tyrannus carolinensis*, Baird—King Bird.
- 130. *Tyrannus verticalis*, Say—Arkansas Flycatcher.
- 131. **Myiarchus crinitus*, Cab—Great-crested Flycatcher.
- 132. **Sayornis fuscus*, Baird—Bridge Pewee.
- 133. **Contopus borealis*, Baird.—Olive-sided Pewee.
- 134. **Contopus virens*, Cab—Wood Pewee.
- 135. **Empidonax flaviventris*, Baird—Yellow-bellied Flycatcher.
- 136. *Empidonax Traillii*, Baird—Traill's Flycatcher.
- 137. **Empidonax minimus*, Baird—Least Flycatcher.
- 138. *Empidonax acadicus*, Baird—Acadian Flycatcher.

FAMILY ALCEDINIDÆ—KINGFISHERS.

- 139. **Ceryle alcyon*, Boie—Kingfisher.

FAMILY CAPRIMULGIDÆ—GOATSUCKERS.

- 140. **Antrostomus vociferus*, Bonap—Whippoorwill.
- 141. **Chordeiles popetue*, Baird—Night Hawk.

FAMILY CYPSELIDÆ—SWIFTS.

- 142. **Chaetura pelagica*, Steph—Chimney Swift.

FAMILY TROCHILIDÆ—HUMMING BIRDS.

- 143. **Trochilus colubris*, Linn—Humming Bird.

FAMILY CUCULIDÆ—CUCKOOS.

- 144. **Coccyzus erythrophthalmus*, Bonap—Black-billed Cuckoo.
- 145. **Coccyzus americanus*, Bonap—Yellow-billed Cuckoo.

FAMILY PICIDÆ—WOODPECKERS.

- 146. **Picus villosus*, Linn—Hairy Woodpecker.
- 147. **Picus pubescens*, Linn—Downy Woodpecker.
- 148. **Sphyrapicus varius*, Baird—Yellow-bellied Woodpecker.
- 149. *Hylatomus pileatus*, Baird—Pileated Woodpecker.
- 150. *Centurus Carolinus*, Bonap—Red-bellied Woodpecker.
- 151. **Melanerpes erythrocephalus*, Swain—Red-headed Woodpecker.
- 152. **Colaptes auratus*, Swain—Golden-winged Woodpecker.

FAMILY STRIGIDÆ—OWLS.

- 153. *Strix pratincola*, Bonap—Barn Owl.
- 154. **Bubo virginianus*, Bonap—Great Horned Owl.
- 155. *Scops asio*, Bonap—Mottled Owl.
- 156. *Otus vulgaris*, Flem.—Long-eared Owl.
- 157. *Brachyotus palustris*, Bonap—Short-eared Owl.
- 158. *Syrnium cinereum*, Gray—Great Gray Owl.
- 159. **Syrnium nebulosum*, Gray—Barred Owl.
- 160. *Nyctale Richardsonii*, Bonap—Richardson's Owl.
- 161. *Nyctale acadica*, Bonap—Acadian Owl.
- 162. *Nyctale albifrons* Cassin—Kirtland's Owl.
- 163. *Nyctea nivea*, Daud—Snowy Owl.

FAMILY FALCONIDÆ.—HAWKS.

- 164. *Falco peregrinus*, Gmelin—Duck Hawk.
- 165. *Hypotriorchis columbarius*, Gray—Pigeon Hawk.
- 166. **Tinnunculus sparverius*, Vieill—Sparrow Hawk.
- 167. *Astur atricapillus*, Bonap—Gos-Hawk.
- 168. **Accipiter Cooperi*, Bonap—Cooper's Hawk.
- 169. *Accipiter fuscus*, Bonap—Sharp-shinned Hawk.
- 170. *Buteo borealis*, Vieill—Red-tailed Hawk.
- 171. **Buteo lineatus*, Jardine—Red-shouldered Hawk.
- 172. *Buteo pennsylvanicus*, Bonap—Broad-winged Hawk.
- 173. *Archibuteo lagopus*, Gray—Rough-legged Hawk.
- 174. **Nauclerus furcatus*, Vigors—Swallow-tailed Hawk.
- 175. *Ictinea mississippiensis*, Gray—Mississippi Kite.
- 176. **Circus hudsonius*, Vieill—Marsh Hawk.
- 177. *Aquila chrysaetos*, Linn—Golden Eagle.
- 178. *Haliaetus leucocephalus*, Say—White-headed Eagle.
- 179. *Pandion haliaetus*, Aud—Osprey ; Fish Hawk.

FAMILY VULTURIDÆ—VULTURES.

- 180. **Cathartes aura*, Illiger—Turkey Buzzard.

FAMILY COLUMBIDÆ—PIGEONS.

181. *Ectopistes migratoria*, Swain—Wild Pigeon.
 182. **Zenædura carolinensis*, Bonap—Carolina Dove.

FAMILY MELEAGRIDÆ—TURKEYS.

183. **Meleagris gallopavo*, Linn—Wild Turkey.

FAMILY TETRUONIDÆ—GROUSE.

184. *Pediocætes phasianellus*, Baird—Sharp-tailed Grouse.
 185. **Cupidonia cupido*, Baird—Pinnated Grouse; Prairie Hen.
 186. **Bonasa umbellus*, Steph—Ruffed Grouse.

FAMILY PERDICIDÆ—PARTRIDGES.

187. **Ortyx virginianus*, Bonap—Quail; Partridge.

FAMILY CHARADRIIDÆ—PLOVERS.

188. *Charadrius virginicus*, Borck—Golden Plover.
 189. **Ægialitis vociferus*, Cass—Killdee Plover.
 190. *Ægialitis melodus*, Cab—Piping Plover.
 191. *Ægialitis semipalmatus*, Cab—Ring Plover.
 192. *Squatarola helvetica*, Cuv—Black-bellied Plover.

FAMILY SCOLOPACIDÆ—SNIPES AND SANDPIPER

193. *Philohela minor*, Gray—Woodcock.
 194. *Gallinago Wilsonii*, Bonap—Wilson's Snipe.
 195. *Macroramphus griseus*, Leach—Red-breasted Snipe.
 196. *Tringa canutus*, Linn—Gray-backed Sandpiper.
 197. *Pelidna americana*, Coues—Red-backed Sandpiper.
 198. *Actodromas maculata*, Cass—Jack Snipe.
 199. *Actodromas minutilla*, Coues—Least Sandpiper.
 200. *Actodromas Bonapartii*, Cass—Bonaparte's Sandpiper.
 201. *Arquatella maritima*, Baird—Purple Sandpiper.
 202. *Calidris arenaria*, Ill—Sanderling.
 203. *Ereunetes pusillus*, Cass—Semipalmated Sandpiper.
 204. *Micropalama himantopus*, Baird—Stilt Sandpiper.
 205. *Symphemia semipalmata*, Hartl—Willet.
 206. *Gambetta melanoleuca*, Bonap—Greater Yellow Legs.
 207. *Gambetta flavipes*, Bonap—Lesser Yellow Legs.
 208. *Rhyacophilus solitarius*, Baird—Solitary Sandpiper.
 209. **Tringoides macularius*, Gray—Spotted Sandpiper.
 210. *Actiturus Bartramius*, Bonap—Bartram's Sandpiper; Field Plover.
 211. *Tryngites rufescens*, Cab—Buff-breasted Sandpiper.
 212. *Limosa fedoa*, Ord—Marbled Godwit.

- 213. *Limosa hudsonica*, Swain—Hudsonian Godwit.
- 214. *Numenius longirostris*, Wils—Long-billed Curlew.
- 215. *Numenius hudsonicus*, Lath—Hudsonian Curlew.
- 216. *Numenius borealis*, Lath—Esquimaux Curlew.
- 217. *Recurvirostra americana*, Gmelin—Avoset.
- 218. *Himantopus nigricollis*, Vieill—Black-necked Still.

FAMILY PHALAROPODIDÆ—PHALAROPES.

- 219. *Steganopus Wilsonii*, Coues—Wilson's Phalarope.
- 220. *Lobipes hyperboreus*, Cuv—Northern Phalarope.
- 221. *Phalaropus fulicarius*, Bonap—Red Phalarope.

FAMILY GRUIDÆ—CRANES.

- 222. **Grus canadensis* Temm—Sand-hill Crane.
- 223. *Grus americana*, Ord—White Crane.

FAMILY TANTALIDÆ—IBISES.

- 224. *Tantalus loculator*, Linn—Wood Ibis.

FAMILY ARDEIDÆ—HERONS.

- 225. **Ardea herodias*, Linn—Great Blue Heron.
- 226. *Herodias egretta*, Gray—Great White Heron.
- 227. *Garzetta candidissima*, Bonap—Snowy Heron.
- 228. *Florida cœrulea*, Baird—Blue Heron.
- 229. **Botaurus lentiginosus*, Steph—Bittern.
- 230. **Butorides virescens*, Bonap—Green Heron.
- 231. *Ardetta exilis*, Gray—Little Bittern.
- 232. **Nycteardea Gardenii*, Baird—Night Heron.

FAMILY RALLIDÆ—RAILS.

- 233. *Rallus elegans*, Aud.—Marsh Hen.
- 234. *Rallus virginianus*,* Linn.—Virginia Rail.
- 235. *Porzana carolina*,* Vieill—Carolina Rail.
- 236. *Porzana noveboracensis*, Cass—Yellow Rail.
- 237. *Fulica americana*, Gmelin—Coot.
- 238. *Gallinula galeata*, Bonap.—Florida Gallinule.
- 239. *Gallinula martinica*, Lath—Purple Gallinule.

FAMILY ANATIDÆ—DUCKS.

- 240. *Cygnus americana*, Sharp—American Swan.
- 241. *Cygnus buccinator*, Rich—Trumpeter Swan.
- 242. *Anser hyperboreus*, Pallas—Snowy Goose.
- 243. *Anser Gambellii*, Hartl—White-fronted Goose.
- 244. *Bernicla canadensis*, Boie—Canada Goose.
- 245. *Bernicla Hutchinsii*, Bonap—Hutchin's Goose.

- 246. *Bernicla brenta*, Stephens—Brant.
- 247. *Anas boschas*, Linn—Mallard.
- 248. *Anas obscura*, Gmelin—Dusky Duck.
- 249. *Dafila acuta*, Jenyns—Pintail Duck.
- 250. **Nettion carolinensis*, Baird—Green-winged Teal.
- 251. **Querquedula discors*, Stephens—Blue-winged Teal.
- 252. *Spatula clypeata*, Boie—Shoveler.
- 253. *Chaulelasmus streperus*, Gray—Gadwall.
- 254. *Mareca americana*, Stephens—Baldpate.
- 255. **Aix sponsa*, Boie—Wood Duck.
- 256. *Fulix marila*, Baird—Black-headed Duck.
- 257. *Fulix collaris*, Baird—Ring-necked Duck.
- 258. *Aythya americana*, Bonap—Red-headed Duck.
- 259. *Aythya vallisneria*, Bonap—Canyass-backed Duck.
- 260. *Bucephala americana*, Baird—Golden-eyed Duck.
- 261. *Bucephala albeola*, Baird—Butter-ball.
- 262. *Histrionicus torquatus*, Bonap—Harlequin Duck.
- 263. *Harelda glacialis*, Leach—South Southerly.
- 264. *Erismatura rubida*, Bonap—Ruddy Duck.
- 265. *Mergus merganser*, Linn—Goosander; Sheldrake.
- 266. *Mergus serrator*, Linn—Red-breasted Merganser.
- 267. *Lophodytes cucullatus*, Reich—Hooded Merganser.

FAMILY PELECANIDÆ—PELICANS.

- 268. *Pelecanus erythrorhynchus*, Gmelin—Brown Pelican.

FAMILY GRACULIDÆ—CORMORANTS.

- 269. *Graculus dilophus*, Gray—Double-crested Cormorant.

FAMILY LARIDÆ—GULLS AND TERNS.

- 270. *Larus argentatus*, Brunn—Herring Gull.
- 271. *Larus marinus*, Linn—Black-backed Gull.
- 272. *Chræcocephalus philadelphia*, Lawr—Bonaparte's Gull.
- 273. *Gelochelidon anglica*, Bonap—Marsh Tern.
- 274. *Thalasseus caspius*, Boie—Caspian Tern.
- 275. *Sterna hirundo*, Linn—Wilson's Tern.
- 276. *Sterna antillarum*, Coues—Least Tern.
- 277. *Hydrochelidon fissipes*, Gray—Short-tailed Tern.

FAMILY COLYMBIDÆ—LOONS AND GREBES.

- 278. *Colymbus torquatus*, Brunn—Loon; Great Northern Diver.
- 279. *Colymbus septentrionalis*, Linn—Red-throated Loon.
- 280. *Podiceps Holbollii*, Reich—Red-necked Grebe.
- 281. *Podiceps cornutus*, Latham—Horned Grebe.
- 282. *Podiceps cristatus*, Latham—Crested Grebe.
- 283. **Podilymbus podiceps*, Lawr.—Carolina Grebe.

APPENDIX C.

GOVERNMENT SURVEYS OF PUBLIC LANDS.

BY C. W. IRISH.

DR. C. A. WHITE, *State Geologist.*

SIR: In accordance with your request, I present the following description of the surveys of the public lands, commonly called "United States Surveys."

The practice of the "Mother Country" in the manner of dealing in lands which she saw fit to "sell and convey" to individuals in the shape of "grants," was imitated by the Colonies, and afterwards by the States. These grants had no definite shape, but were of all sizes and bounded in all manner of ways. The boundary lines were made to conform to the windings of any stream that happened to be favorably situated, and in the absence of such convenience, the track of an ancient highway, or any other landmark, natural or artificial, was taken as a boundary. The courses of the boundary lines of the grants were *magnetic*. That is to say: The angles or bearings of the lines were referred to the magnetic meridian for direction. This system of surveying by magnetic bearings had its origin at a time when the general belief that the direction of the magnetic meridian, or, if you please, the direction of the compass needle was invariable. This, however, is not the case. The direction of the needle is constantly changing, and as a consequence, the magnetic bearing of to-day, from a given point to another, will not be the bearing between the same points next year. Thus the attempt to fix the boundaries of a tract of land in an invariable manner by the use of such variable means as these above described, resulted in fixing variable boundaries and consequently produced much perplexity and vexatious litigation.

The man who conceived the idea, involving the principles of the present system of United States Surveys, was indeed a public benefactor, as well as a thorough scholar, for he brought order out of the chaos of perplexities and vexations involved in the plan of surveying just described. In doing this, he laid astronomy, mathematics, and mechanics under contribution; and at the same time that he gave to the United States a system of surveying at once accurate and simple, his plan for getting the direction of the lines used in bounding the lands surveyed, necessitated the invention of a new surveying instrument; the most accurate kind of compass used by surveyors. This new plan adopted by the United States government has for its basis the invariable direction of the true meridians. All bearings taken from these meridians are called true bearings to distinguish them from magnetic bearings; and in their direction are invariable as is the meridian from which they are measured.

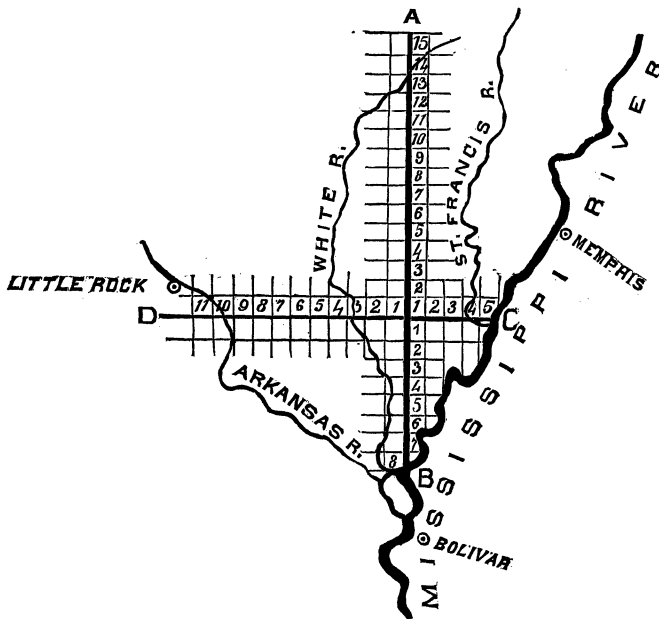
The parallels of latitude are also used in the new system as a basis from which to measure distances. Consequently the United States system of Public Surveys, consists in the use of the true meridians from which to get distances and directions or bearings, and the parallels of latitude from which to measure distances.

It is called a rectangular system—that is, all its distances and bearings are measured from two lines which are at right angles to each other; the two lines or bases being always a true meridian, and a true parallel of latitude.

The principal lines used in Government Surveys are five in number, and are called—named in the order of their establishment—Base Lines, Principal Meridians, Township Lines, Section Lines, and Correction Lines. There are several other lines used, but they are of interest only to the surveyor, and do not properly come within the limits of this explanation.

By the rule, all north and south lines must be run upon true meridians, and all east and west lines upon true parallels of latitude.

FIG. 97.



In locating the base lines and meridians, which is the first step in a government survey, the initial point, or the place from which they start, is generally located at or near some natural landmark, merely for the purpose of ready identification. But the position of the starting point does not depend upon the invariability of such landmark for its stability. For in case of the removal of the landmark, the starting point can be readily identified by its latitude and longitude, and the reference marks made near it—hence the landmark, be it the mouth

of a river, or the top of a mountain, is merely a reference point; but whatever point is chosen, the base line and meridian start from that point, the base running east and west, the meridian north and south.

Figure 97 is intended to show the starting point of the Iowa surveys.

The meridian, A B, passes through the mouth of Arkansas river, in Arkansas, and runs northward from B, while the base line, C D, passes through the mouth of the river St. Francis, in the same state, and runs westward from C, crossing the meridian at a point forty-eight miles north of the mouth of Arkansas river. This point at which they cross is the beginning of all the measurements. The line A B is the fifth meridian. The small squares are intended to represent townships, and are numbered, as in the figure, North, South, East, and West, from the intersection of base and meridian.

After the establishment of the base line and meridian, they are measured into half mile, mile, and six mile spaces. The points at the ends of these divisions are well marked, that they may be identified and distinguished from each other years after, and serve as starting points for other surveys.

The next step in the process is to divide the country lying along these lines into spaces six miles square. This is called townshiping the land, and all the lines of these townships begin at the ends of the six mile spaces, on the base and meridian, and are run parallel to these two guides.

It is well known that the meridians of the earth are not parallel to each other, for they begin at the equator with a definite width between them, say sixty-nine and one-half miles to a degree, and gradually converge until they meet in the poles. Now, these north and south township lines being run on true meridians, as a matter of course, must converge, and in consequence, the north side of a township must be less in width than its south side. This is not the case with the east and west lines, for they, being run on true parallels of latitude, do not converge, but remain of equal width however far from the meridian they may be traced. Then, for the want of parallelism between the east and west sides of the townships, an allowance must be made as it amounts to about forty-three feet to a township between the parallels of 41° and 42° north latitude. That is to say, the north side of a township between 41° and 42° of latitude measures forty-three feet less than its south side. This is partly allowed for by the use of correction lines, which are run on true parallels of latitude, serving the purpose of a new base. Upon this new base the half mile, mile, and six mile points are again established, and from these points a new set of north and south lines are measured.

Figure 98 is a map of the east half of the State of Iowa, showing that part of the fifth principal meridian, A B, which lies within the State. G H and E F are the 1st and 2d correction lines. C D is the fourth meridian, from which the surveys of Illinois and Wisconsin are made. The small squares are intended to represent townships. By reference to the figure it will be seen that township lines on the south of the correction lines all intersect them to the east of the lines on the north side. This is due to the fact already stated. The distances on the north side are all measured even six miles, while the distances on the south side

are all less than six miles by the amount of the convergence for the distance which the township lines have been run. The townships of which we have been speaking are all *intended* to be six miles square, and to be divided by lines running parallel with their sides, into thirty-six equal parts, called sections. The dividing lines, being one mile apart each way, the sections are, of course, one mile square and contain six hundred and forty acres.

FIG. 98.

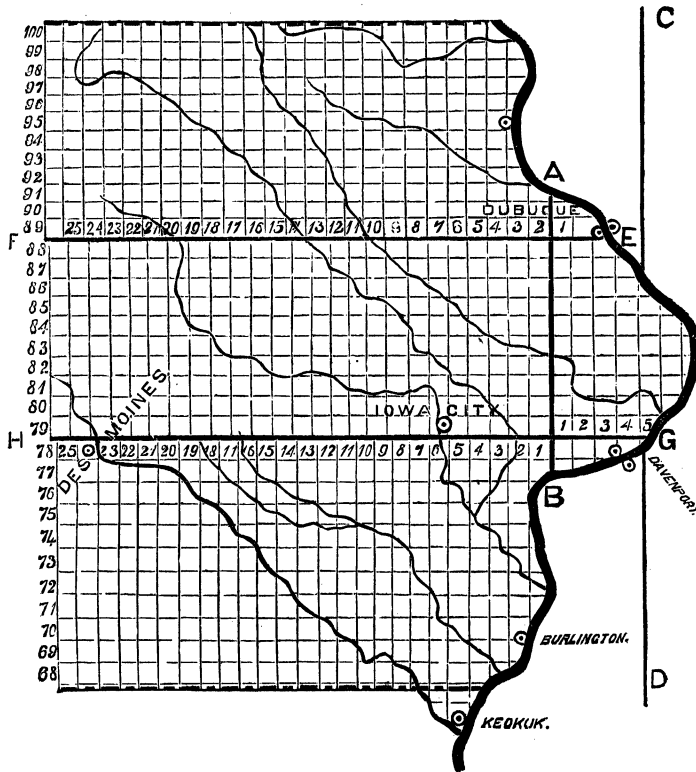
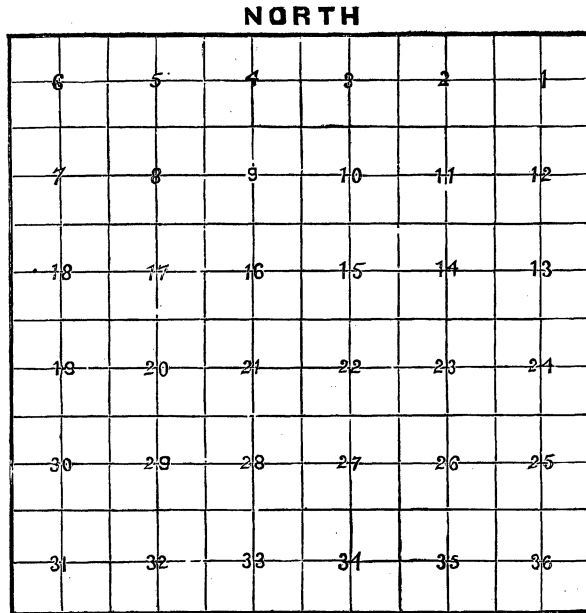


Figure 99 is intended to represent such a township. The sections are always numbered from 1 to 36 in regular order, beginning with the one in the northeast corner, from thence to the west, thence back to the east, and so on, as will be seen by a glance at the figure—the southeast corner section being always numbered 36. The lines bounding each section, are called “Section Lines,” to distinguish them from the other lines used in the survey. They are marked at the corners of each section by what are called, “Section Corners.”

Before proceeding further, it will be necessary to explain the different kinds of corners used in making the various lines of a survey. They are: “Initial-

Monument," "Township Corners," "Section Corners," and "One-fourth Section Corners," each having its own peculiar marks.

FIG. 99.



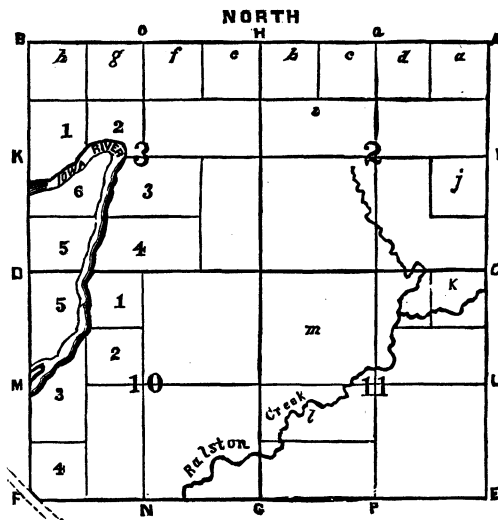
The manner of marking these corners is various, and it is necessary to give a description. Township corners, when located in timbered lands, are marked by a post. This post is about five inches square, and set in the ground so as to project above the surface about three feet. The corners of the post are set to the north, south, east, and west, each corner having six notches cut in it. Two trees are then marked with a blaze facing the post, the bearing and distance of each from the post is then taken and put in the notes. If the township corner is located in the open field and no timber near, a post is set as above described, and a mound of earth, three feet high, having a base five feet square and top two feet square is raised around it. The earth for this mound is taken from two pits, one to the north, the other to the south of the mound. They are square in shape, and like the mound, have their four corners directed to the north, south, east, and west. Section corners, in a timbered tract, are marked by a post three inches square and two feet high. The corners of the post are set to the cardinal points the same as township posts; but the corners are notched so as to show the number of miles which the post stands from the township lines next north, south, east, and west of it. Thus in figure 3, a section corner post at the corner common to section 9, 10, 15, and 16 would have on its east corner 3 notches; on its south corner four notches; on its west corner three notches; and on its north corner

two notches; the number of the notches on its corners thus being equal respectively to the number of miles that the post stands from the adjacent township lines. The position of the post is also marked by two trees, as described for a township corner. In open ground, with no timber near, the section corner is marked by a post as above described and also by a mound of earth. The pit from which the mound to form a section corner is taken, is situated on the south side of the mound at a distance somewhat less than that in the case of a township corner. The mound is also less in size than a township corner mound, being at the base four feet square, at the top one and a half feet square and two and a half feet high. The post for a quarter section corner is only flattened on two opposite sides, and in timber its position is denoted by two bearing trees, and on open ground the corner is marked by a pit and mound of the size used in marking a section corner. The position of the pit differs from that used in marking a section corner by being placed to the *east* of the mound. Its distance from the mound, however, is the same as the pit from a section corner mound.

Upon the sides of the stakes used in marking a township corner will be found the numbers representing the adjacent townships. Upon the section corner stake will be found the numbers of the adjoining sections, while upon the quarter-section stake is marked simply " $\frac{1}{4}$ S."

The townships, as stated, are numbered from the starting point in north, south, east, and west directions. Iowa lies north of the base line, and to the east and

FIG. 100.



west of the meridian. The townships starting at the base and lying along the meridian are said to be in Range 1, West or East of the 5th Principal Meridian as the case may be, and the next tier is Range 2, West or East, and thus in

continuous numbers to the limits of the survey. The townships in these ranges are numbered from south to north, beginning with the first one north of the base which is numbered "1 North," and so on in continuous numbers to the north limits of the survey.

In sub-dividing a township, the measurement begins at the southwest corner of section 36, and progresses northward and westward. This proceeding throws all the errors of measurement into the lines adjoining the *north* and *west* sides of the townships, giving what are called "Anomalous Sections," they being either greater or less than one mile square by the amount of the error of measurement.

These anomalous sections are numbered 1, 2, 3, 4, 5, 6, 7, 18, 19, 30, and 31. The rest of the sections in a township are taken to be one mile square.

Figure 100 is a copy of the Government survey in township 79, north range 6, west of the Fifth Principal Meridian. It comprises four sections of the above numbered township, and they are taken so as to show the manner of sub-dividing sections. The lines *EF*, *CD*, and *AB*, with *AE*, *HG*, and *BF*, are sectional lines. *AB* is also a township line. The lines *LM*, *IK*, and *QP* and *ON*, are quarter-section lines, and divide sections 2, 3, 10, and 11 into quarter-sections, as at *m*, which is the northwest quarter of section 11. These quarter-sections are again divided into halves and quarters, as at *i*, which is the south half of the northwest quarter of section 2; at *j*, the northeast quarter of the southeast quarter of same section; while at *k* is the northeast quarter of the northeast quarter of section 11, and at *l*, the north half of the southwest quarter of section 11. In the figure, the numbers of the section are written at their centres.

The government makes no smaller sub-division than forty acres, except where errors of measurement produce such a result in the anomalous sections.

When the section lines cross the meandered streams, small, awkwardly shaped pieces might occur. To obviate this difficulty the land is divided into convenient shaped lots, bounded on one side by the banks of the river, and on the other sides by the regular lines of the sections. These divisions are called "Lots," and are shown in Fig. 4, on the left. They are numbered on the figure as found on the government map of the survey, and are referred to as "Lot No. 1 in section 3, or Lot No. 5, in section 10, all of township 69, North Range 6 west of the 5th P. M."

In Fig. 100, on the upper, or north side, the squares marked with the letters, *a*, *d*, *c*, *b*, *e*, *f*, *g*, and *h*, are technically called the fractional forties, containing more or less than the one-sixteenth part of a section, or forty acres, as the variation in error of measurement happens to make them. They are referred to as the fractional part of a section: thus the lot marked '*a*' is referred to as the northeast fractional quarter of the northeast quarter of section two.

The lots marked *e* and *f*, are referred to as the north fractional half of the northeast quarter of section three.

For sections lying along the west line of a township the fractional lots are numbered and referred to as described in Fig. 4. Thus it is that a piece of land, however situated within the bounds of the United States Surveys can be referred

to and described with the greatest certainty, and its dimensions or area in square acres or miles be ascertained with all the precision that the skill of the surveyor will warrant.

And further, the manner in which the boundaries are marked and perpetuated, is such as to make the lines established as immutable as the Earth itself.

I remain,

Your obedient servant,

C. W. IRISH,

Iowa City, Iowa.

Sept. 20th, 1869.

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ERRATA.

NOTE.—The authors of the chapters and articles contained in this report had no opportunity to make final corrections of the proof. Some of them had no opportunity to correct at all.

VOLUME I.

Title of first leaf of Map-model, in a few copies, for "CREACEOUS," read "CRETACEOUS."

VOLUME II.

Throughout the volume, wherever "oxyd" occurs, read "oxide."

Page 16, bottom line, for "interval," read "intervale."

Page 25, 13th line from the bottom, for "No. 5," read "No. 3."

Page 25, 15th line from the bottom, for "*Pernopecten*," read "*Entolium aviculatum*.
M. & W."

Page 30, 5th line from the top, for "outcrops," read "outcrop."

Page 31, 16th line from the top, for "*Mekella*," read "*Meekella*."

Page 31, 20th line from the top, for "*Martinto*," read "*Martinia*."

Page 37, 15th line from the top, for "*Spiriferina Kentuckensis*," read "*Spiriferina Ken-
tuckensis*."

Page 43, 18th line from the top, for "*Meekelia*," read "*Meekella*."

Page 50, 8th line from the top, for "with usual," read "with the usual"

Page 50, 13th line from the top, for "firmness," read "fineness."

Page 58, 6th line from the bottom, for "South Raccoon river," read "South river."

Page 62, 11th line from the top, for "formed," read "found."

Page 64, 13th line from the bottom, for "Panora," read "Panora coal."

Page 75, 20th line from the bottom, for "but," read "that."

Page 92, 17th line from the bottom, for "slight," read "slightly."

Page 100, 5th line from the bottom, for "Brushey's," read "Bruchey's."

Page 101, 3d line from the top, for "No. 5," read "No. 4."

Page 102, 6th line from the bottom, for "where," read "whose."

Page 105, 11th line from the top and 12th line from the bottom, for "Brushy's," read
"Bruchey's."

Page 106, 3d line from the top, for "Brushy's," read "Bruchey's"

Page 121, 16th line from the bottom, for "at," read "of."

Page 128, 6th line from the bottom, for "which has averages," read "which averages."

Page 130, 13th line from the bottom, for "Burrick," read "Butrick."

Page 131, 4th line from the top, for "where," read "whose."

Page 142, 1st line from the top, for "quietly," read "gently."

Page 142, 13th line from the bottom, for "interruptedly," read "uninterruptedly."

Page 153, 2d line from the bottom, for "probably," read "embracing probably."

Page 155, 13th line from the top, for "intervals," read "intervalles"

Page 173, 10th line from the bottom, for "deposits," read "deposit"

Page 179, 18th line from the bottom, for "varied," read "viewed."

Page 171, 2d line from the bottom, omit "at."

Page 182, 13th line from the bottom, for "on," read "by."

Page 187, 7th line from the bottom, for "rand," read "range."

- Page 193, add at bottom, "No. 1. Soft, yellowish sandstone, exposed 4 feet or more to level of river."
- Page 194, 2d line from top, omit "with."
- Page 226, 9th, 10th, and 12th lines from the bottom, for "Osceolo," read "Osceola."
- Page 227, 17th line from the bottom, for "Lincoln," read "Osceola."
- Page 230, 14th line from the top, add "exposure of stratified," after "single."
- Page 234, 10th line from the top, for western," read "eastern."
- Page 238, 15th line from the bottom, erase "of," after "character."
- Page 248, 16th line from the bottom, for "thick," read "feet."
- Page 271, 7th line from the top, for "coal-measures," read "coal-beds."
- Page 299, 4th line from the bottom, erase "other."
- Page 319, 10th line from the top, for "least," read "best."
- Page 346, 12th line from the top, for "Magnesian," read "Magnesium."
- Page 346, 2d line from the bottom, for "1 and 5," read "1 and 2."
- Page 347, for "*Gamble & Co.*," read "*Gamble & Co.*"
- Page 347, 18th line from the bottom, for "Magnesian," read "Magnesium."
- Page 350, 5th line from the top, for "seventy-eighth," read "seventy-eight."
- Page 352, 8th line from the top, for "limestone," read "lime."
- Page 352, erase "SULPHATES OF THE ALKALINE EARTHS," and insert the same before *Epsomite* on the next page.
- Page 355, 16th line from the top, erase "and " after "sodium."
- Page 357, 6th line from the bottom, for "150°" read "105°."
- Page 362, 10th line from the bottom, for "thickness" read "thinness."
- Page 363, 17th line from the top, for "Total volatile, 47.72" read "Total volatile, 47.12."
- Page 372, 3d line from the top, for "upper " read "lower."
- Page 375, 20th line from the bottom, for "*townshp* 83" read "*township* 88."
- Page 377, 16th line from the bottom, for "northeast " read "northwest."
- Page 382, under "No. 11," for "5.59 " read "5.69."
- Page 387, 9th line from the top, for "No. 2," read "No. 1."
- Page 388, 4th line from the top, for "56.88 " read "54.88."
- Page 388, 6th line from the bottom, for "gray " read "red."
- Page 393, 4th line from the bottom, for "coke " read "coal."
- Page 398, 6th line from the top, for "No. 1 " read "No. 4."
- Page 400, first line of figures in the table, for "85.39 " read "51.39."
- Pages 373, 386, and 389, the two sets of figures opposite, respectively, "Total combustible" and "Coke," are, the upper line for undried coal, and the lower for dried coal.

